TYPOLOGY OF CROP CULTIVATION AND LEVELS OF AGRICULTURAL PRODUCTIVITY IN GANGA-YAMUNA DOAB

DISSERTATION

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BY

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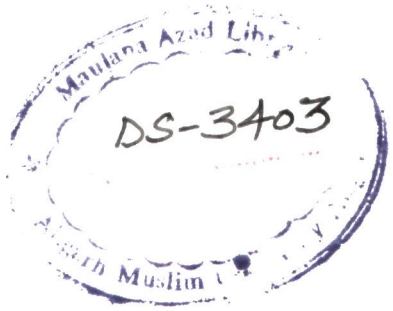

Dedicated
to
My Beloved Parents

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CERTIFICATE

This is to certify that **Mr. Abdul Wahab** has completed his M.Phil. dissertation entitled **"Typology of Crop Cultivation and Levels of Agricultural Productivity in Ganga-Yamuna Doab"** under my supervision. The work presented in the dissertation in my opinion is fit for evaluation.

H. Rahman.

(Dr. HIFZUR REHMAN)

CONTENTS

PREFACE

The major objectives of the agricultural development in parts of Uttar Pradesh are to bring about reduction in regional inequalities in the pace of development. The process of agricultural development in the backward districts of the state should be upgraded while maintaining the progress of those districts which are agriculturally more developed. The diffusion of agricultural skill and technology in less developed districts can bring greater improvements in raising agricultural productivity. There is a marked variation in agricultural productivity per hectare in the districts of lower Doab as compared to the upper Doab districts. While making these imparatives it is necessary to measure the agricultural productivity in the districts forming the Ganga-Yamuna region, so that plans can be formulated to reduce regional imbalances.

This work spreads over four chapters to study the region with more detials. Chapter 1 deals with the structure and relief, drainage, soils and climate. Chapter 2 is devoted to review of literature and bring out some of the studies which have been taken up on landuse and agricultural typology. Chapter 3 examines in detail the landuse and cropping patterns and trends of growth in area, production and yield of crops grown in the Doab region. Chapter 4 considers the conceptual and methodological frame pertaining to crop productivity, and attempts to determine productivity in the Doab region.

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Abdul Wahab

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INTRODUCTION

Cultivation of crops in India dates back to the time of Indus valley civilization. Even since, it has continued to be the leading occupation and the mainstay of the population of the country. About three-fourth of the country's population lives in rural areas and engaged in agricultural activities. Indian agriculture, however, is predominantly of subsistence type. Nearly three-fourth of the area under available for cultivation is devoted to the cultivation of food crops.

Crop yields in India are lowest in the world. A large number of natural and socio-economic factors have been responsible for the low productivity. Despite the best efforts of the concerned governments at the centre and state, the yield per hectare has not been satisfactory. Comparing the yield per hectare in India with the yield in some of the advanced countries of the world, it is found that India lags behind. The tools and implements used by the farmers are inefficient. The methods of farming over a large part of the country are traditional and very little use of chemical fertilizers is made. There are financial constraints on part of the purchase of inputs and marketing facilities for sale of crop produce. There is no security for crop failure during the growing season. The lack of the scientific approach for crop production and occurrence of unusual flood and drought in most parts of the year adversely effect the agriculture. These factors to a large extent are responsible for reducing the yield. Further, the present rate of population growth has also contributed to a certain extent to reduce the per capita availability of foodgrains. The country is placed in such a

situation which needs some integrated planning to solve the problem, and ensure to provide required quantity per capita of foodgrains.

The present study is an attempt to measure the crop productivity with respect to selected crops in Ganga-Yamuna Doab. The region lies between 25°0' and 30°31' north latitudes and 77°0' and 82°0' east longitudes. The Ganga-Yamuna Doab covering an area of about 58,400 sq.km., is nearly 832 km. long and has a maximum width of about 104 km. to include 22 districts of the state of Uttar Pradesh. According to 2001 census the total population of the Doab stands as 51500619 persons with an average density of 725 persons per sq.km.

There is a marked variation in the landuse pattern in Ganga-Yamuna Doab. The yield of crops varies from one district to another in the region. At present mechanization has been on the way on tradional farms for cultivation in the study area. Low yield in crops results in agricultural backwardness, which leads to poor investment in cultivation. There is little capital formation with respect of land management, poor irrigation facilities, absence of farm buildings, agricultural machinery and equipments, warehouses and market, all of these affect the farmer's income.

For reducing the regional variations and maximizing the crop productivity per unit area; it would be of great importance if the region is divided into high, medium and low productivity regions.

Agricultural "productivity can be evaluated on the basis of a number of different methods by computing productivity, the region can be

divided into the areas with high, medium and low productivity. It has also been attempted to examine the factors responsible leading to variations in the levels of agricultural-productivity in Ganga-Yamuna Doab. Thus the analysis would reveals as to which factors and to which mangnitude is responsible for variations in productivity.

The Problem

The present study examines regional variations in crop cultivation and the levels of agricultural productivity by delineating the areas of high, medium, low productivity in the districts of the Ganga-Yamuna Doad. Agricultural productivity infact is the degree to which man has able to exploit the resources in an area for the purpose of crop production. Levels of agricultural productivity in a region reflect spatial variations and the efficient use of resources. Variations in productivity reflect the differences in economic progress which the region attains.

Data base

Crop productivity and its levels were calculated with the help of data relating to area and production of all the important crops grown in the region. The present study is based on the secondary source of data obtained from the Directorate of Agriculture, Lucknow for the period extending from 1990-91 to 1999-2000. District has been taken as the unit of study. The Ganga-Yamuna Doab consisted of 16 districts in 1990-91 and 6 new districts were created later on to form 22 districts in the year of 1997-98. The entire

reigon can be sub-divided as : the upper Ganga-Yamuna Doab, central and the lower Doab.

Methods of Productivity Measurement

There are vairous methods which have been used by different scholars to measuring agricultural productivity. Considering the most appropriate of these, W.Y. Yang's 'Crop Yield Index' method has been applied.

Chapter I

PHYSICAL SETTING OF GANGA-YAMUNA DOAB

A. Structure and Relief

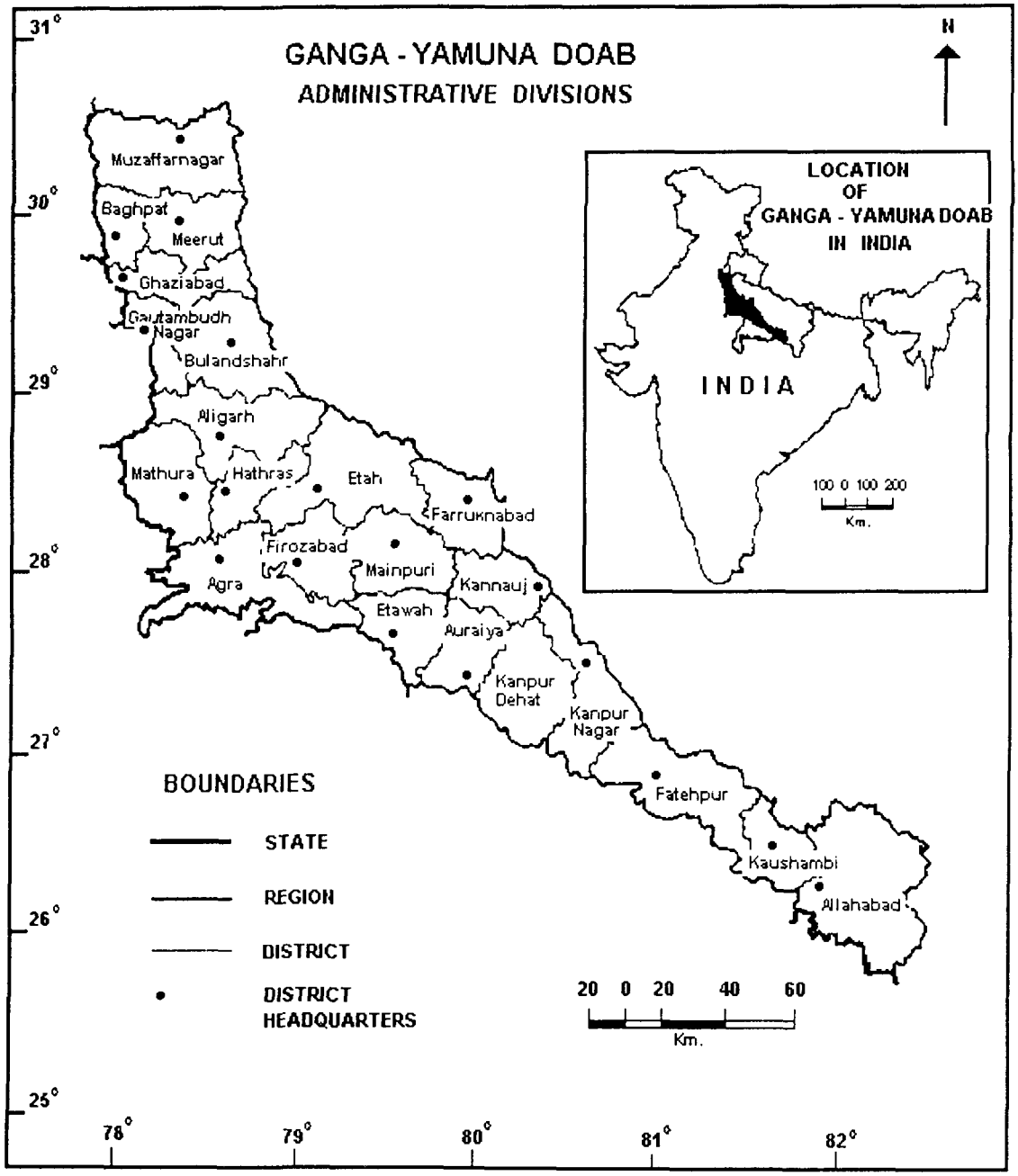
The Ganga-Yamuna Doab extends from 25°0' to 30°31' North latitudes and 77°0' to 82°0' east longitudes. The Ganga-Yamuna Doab structurally forms a part of the Indo-Gangetic plain which lies between the Peninsular India and the recently built Himalayan chain. It has been filled by the alluvium brought down by the rivers descending from the Himalayas. The alluvial deposits in the Doab consist of sediments, silts and clays with occasional occurrence gravel beds, which can divided into two classes :

i) Newer alluvium known as KHADAR

ii) Old alluvium known as BHANGAR

The khadar and bhangar lands correspond in age to the Pleistocene and recent period of geological history respectively.

The Ganga-Yamuna Doab on the contrary exhibits somewhat more stable *bhangar* lands where sediments rise from 15 to 60 cm. above the adjoining flood plains. The origin of the plain has been a matter of great controversy. Edward Suess, holds a view that it is a "foredeep infront of the resistant mass of the peninsula, when the Tethys sediments were thrust southward and compressed against them". The Peninsula is regarded as rigid stable mass and the central Asia as the moving segment of the crust. The foredeep was gradually filled in by the eroded material from the Himalaya and the old shield of the south and thus the plain came into existence.



SOURCE : Based upon survey of India map

Fig. 1

On the basis of the geodetic observation S.G. Burrard, found a zone of low density underlying the Indo-Gangetic alluvium, and concludes that the presence of this underlying matter of low density suggests that the Himalayan foredeep has been caused by the tension in the crust and that it was infact a crustal opening or rift.

Another view was put forward by Oldham, who suggests, that the crust of the earth is floating upon a fluid magma and therefore, a trough has been created by sinking of the crust under the weight of alluvial deposits brought down from the mountains by the rivers.

A more recent view regards this region as a 'sag' in the crust formed between the northward drifting Indian sub-continent and comparatively soft sediments accumulated and lifted into the mountain system.

As regards the nature of deposits of the Ganga-Yamuna Doab, it has been accepted that the foredeep was filled by the material brought down by the rivers and other natural agents. These deposits are the silt, mud, and sand brought by the great rivers.

The Siwalik hills lie along the northern border of the district of Saharanpur. The hilly tract lying between the gorge of the rivers Ganga and Yamuna and extends to about 46 km. To the south of the Siwalik hills lies the sub-montane tract, locally called as *Ghar* which relate to the *bhabar* of the northern Uttar Pradesh. The sub-montane tract is separated from the plain of upper Ganga-Yamuna Doab by a fertile river valley. The surface of the Ganga-*Khadar* is characterised by the presence of a number of swamps and ox-bow lakes.

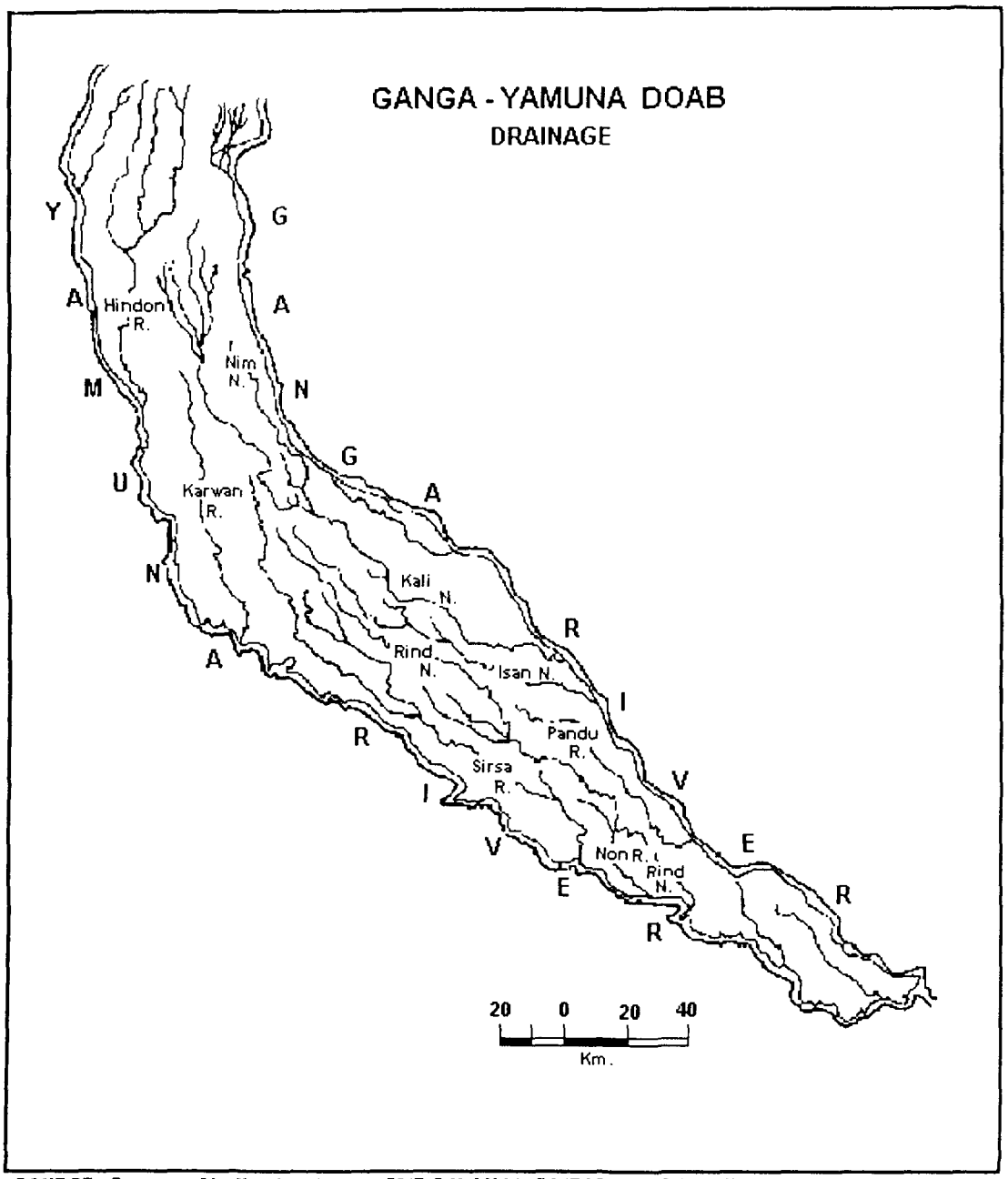
The central Ganga-Yamuna Doab is almost a level plain and homogenous in character. Most of the area is a flood plain, occupied by the *Khadar* and *bhangar* lands and physical features are characterised to a limited extent by the rivers that flow through this region. The *Khadar* land varies in width along the rivers of Ganga, Kali and Yamuna. The Ganga and Yamuna Khadar lands also differ in productivity. This is the largest physiographic division and includes the entire area of the district of Mainpuri and parts of Etah and Aligarh districts. The lower doab is narrow in width and the rivers of Ganga and Yamuna make a triangle at the confluence in Allahabad district.

B. Drainage

The Ganga and the Yamuna are the two principal rivers of the Doab. These rivers rising in the Himalayas and pass through the Siwalik ranges, enter the plain from the northwest in the state and flow in southeast direction. Both of them are known as the master streams because of they possess sufficient water through out the year.

The Ganga takes its water from the Himalayas and move towards the south and covers a distance of 300 km. Cutting the Siwaliks through a gorge, touches the plain in the north at Hardwar, after covering a distance of 288 km. in Upper Himalayas. The mainstream of the river Ganga at Hardwar is known as Nildara.

The Ganga rises in the snow-bound Himalayas and at initial stage it is known as the Bhagirathi. After passing through the mountainous zone, the river forms the eastern boundary of the district of Dehradun, where it is named as the Ganga. There are many tributaries of the river Ganga that drain



SOURCE : Survey of India sheets no. 53(F,G,H,J,K,L), 54 (E,I,M,N), 63 (A,C,D)

Fig. 2

in the eastern and the central portions of the Doab and play an important role in the cultivation of crops and affect the levels of agricultural productivity in the area. The tributaries of the Ganga in the upper Doab are hilltorrents which after rising in the Siwaliks and crossing the *Khadar* in the district of Saharanpur join the Ganga river in the district of Muzaffarnagar. The Solani is an apt example of such tributaries. Besides the Solani, the Kali and the Isan are the other tributaries of the Ganga. They originate in the districts of Muzaffarnagar and Aligarh and merge with Ganga in the districts of Farrukhabad and Kanpur respectively.

The western boundary of Doab is well defined and demarcated by the river Yamuna, whose deep valley in northern part separates the state of Haryana from the Doab. This river also rises in the Himalayas and after travelling a distance of 200 km it enters the plain through the Siwalik ranges. The river Yamuna like the Ganga also has its source in the snowy peaks of the Himalayas. The valley through which the river passes the mountainous region is bounded by high peaks. In the middle part of the district of Muzaffarnagar, it makes loops and sharp bends passing along the western border of the districts of Baghpat, Ghaziabad, Gautambudh Nagar and Aligarh near the village Juppa. It flows through the districts of Mathura and Agra and Ultimately meets the Ganga at Allahabad.

The bank of river Yamuna is subjected to little variations as the river flows through a well defined and deep bed. The width of the river varies from 34 metres in the months of summer to 90 metres in rainy season.

The rivers Ganga and Yamuna joining at Allahabad divide the district into three parts. A portion of the Doab comprising the tehsils of Chail Sirthu and Man Jhanpur, have the soils which are more fertile. In most parts of the district of Allahabad, the rivers Ganga, Yamuna, Tons, Barna Sasur, Khaderi carry off the drainage with great rapidity, but in a few tracts the natural out-let form the surface water which are inadequate and form some large and shallow jhils.

C. Soil

The soils of the Ganga-Yamuna Doab are mainly alluvial in nature and fall into two distinct divisions :

i) The old alluvium or *bhangar*

ii) The new alluvium or *Khadar*

The *Khadar* lands are not in any way of agricultural significance. The Yamuna *khadar* in the district of Aligarh for examples, is of poorest description possessing a coarse grained silty texture with a rather hardy nature and difficult to till.

The *bhangar* lands are well drained mostly loamy in nature and have agricultural significance. The *bhangar* soils vary from grey brown to dark-brown in colour and characterised with sandy loam to stiff clay depending upon the local topography and drainage.

At some places, however, these soils are more adversely affected by salinity or alkalinity. Such areas are known as *Usar, Kalar* or *thur* at different locations.

The sandy tract occurs mainly along the river beds of the rivers of Ganga, Yamuna and Kali Nadi. This tract receives silty and sandy deposits each year as a result of overflooding of the rivers. The colour of the soil varies from light-grey to ash-grey and the texture from sandy to silty loam. The ground water table usually confines near the surface. The soils are, therefore alkaline in reaction and saline in nature. The soil profile exhibits many distinct immature stratified layers of younger soils in precarious conditions. Sugarcane and barley cultivation predominate the area.

The sandy loam tract covers a sizeable portion in the area. This soil is homogeneous in character and topography is remarkably raddish-brown in colour. Here ground water table confines at a low level of about 16 metres from the surface.

The loamy tract extends from north to south in between the Khadar lands of the rivers Ganga and Kali Nadi. The soil texture varies from good quality loam to sandy-loam. A clay-loam tract runs from north to south almost parallel to the course of the river Yamuna, it is narrow in the north but broaden towards south.

The soil is stickey and generally contains clayey or clayey-loam particles as the constituents. It is grey, ash-grey or dark-grey in colour.

Usar soils are extremely irregular in their occurrence and usually found inter-sparsed with cultivable lands. Experiments conducted to reclaim usar soil, with the application of gypsum and molasses have produced encouraging results in some of the district of the Doab.

D. Climate

The climate of the Doab is characterised by a seasonal rhythm, which is produced by the reversal of prevailling winds which takes place twice in a year. In one part of the year when the northeast monsoon is prevalent, the air is generally cold and dry as compared to the other part. When the southwest monsoon is prevalent, the circulation of the air over the plain is experienced from east to west being moisture laden and brings copious rain.

During the season of northeast monsoon, the pressure gradient is not very steep and the velocity of wind does not exceed from 3 to 4 km/hr.. During the season of southwest monsoon, the pressure gradient is sharp and the winds below with considerable force. The seasonal rhythm of monsoon reversal is well marked and a slightest variation has an adverse impact on agricultural operations. With comparatively greater incidence of winter rain, the region distinguishes itself from eastern plain. The Doab area receives from 60 to 100 cm rainfall annually, of which about 90 per cent occurs during the months of July to August.

The climate of the Ganga-Yamuna Doab, is characterised with four distinct seasons :

i) The cold weather season (December to February).

ii) The hot weather season (March to mid-June).

iii) The season of rains (mid-June to September)

iv) The season of retreating monsoon (October to November).

(a) The cold weather season

Winter season is marked by a fall in temperature and prevalence of dry and chilly westerly winds with clear skies. The months of December and January are the coldest in which the maximum and minimum temperatures sometimes fall as low as 21°C and 6°C for a short period. The cold waves coming from the Himalayas, also bring a fall in temperature. The winds blow normally from west and northeast to east and southeast. These wind are dry and light and generally blow at an average speed of about 32 km. per hour. During the months of January and February western depressions enter India through Iran, Afghanistan and Pakistan and more eastwards upto west Bengal and provide some rain in Doab.

The total amount of rain occuring during winter season does not exceed from 4 to 5 cm and the amount of rain decreases from west to east. The winter rains are not sufficient for the crops grown in *rabi* season especially the high-yielding variety of wheat, which requires at least 4 or 5 waters through irrigation.

Frost and hails sometimes occur during these months. Frost is locally known as *pala*, usually occurs early in the month of January, when the *rabi* crops are immature and liable to injury. Hail may occur and it can damage the plants when they are at the stage of flowering. In these months heavy mist and fog locally known as *Kohra* often occurs at night and lasts until the sun rise. Occasionally, the fog becomes so intensive and if it is prolonged may damage the *rabi* season crops.

(b) The Hot Weather Season

The hot weather season is characterised with an increasing temperature and lowering of pressure. The hot weather season extends over the months of March to June. Since the begining of the month of March the temperature begins to increase continuously and the nights still remain cool. The months of May and June record exceptionally high temperatures as high as 44°C and even more than 46°C. The days are characterised with intensive heat, dry air and low humidity. In hot season winds blow from west, northwest to east, southeast. In the months of may and June a hot wind known as *loo* originates as a result of the heating of the surface air and rapid increase of temperature. The occurance of dust storms associated with the thunderstorm locally known as *andhi*, usually occurs in the afternoons and are accompanied by squally winds, thunder storms bliding dust and sometime associated with rains.

The average rainfall for the hot weather season is very meagre ranging between 18.5 and 61 cm. The rainfall in the hot weather season if it occurs helps in the early ploughing and sowing of land for some *kharif* crops.

(c) The Season of Rains

The season of general rain generally commences from the second week of the month of June and continuous upto October. Due to excessive heat over the land area, a low pressure developes in the northern part of India and by the middle of June, it brings a complete reversal in the air movement. The winds begin to move from the Indian ocean to landmass in the southeasterly direction. These moist winds originating in the Indian Ocean

bring heavy downpoures which reduce the temperature from 44°C to 27°C in the month of June to about 30°C and recorded to about 25°C in the month of July. The relative humidity increases and is recorded to about 80 per cent in the month of August. The average rainfall received is recorded to the extent of 75 cm., and the amount decreases west and south wards. In the month of September, the rains normally slacken and rainless intervals become longer. The relative humidity still remains high.

(d) The season of Retreating Monsoon.

The retreating phase of monsoon begins from the month of October and continues until the end of the month of November. In the month of October, the mean monthly temperature is recorded at few stations (25°C at Roorkee) and (27°C at Meerut). The mean maximum temperatures during this month at Roorkee and Meerut are 35°C and 33°C respectively, while the mean maximum temperature 17.4°C and 18°C respectively. In the month of November there is further decrease in the mean monthly temperature which remains about 20°C at Roorkee and 21°C at Meerut. The relative humidity at Roorkee in the months of October and November is recorded as 75 and 77 per cent respectively. The total amount of rainfall during the retreating monsoon period remains less than 2.5 cm at all the stations.

Chapter II

STUDIES IN LAND USE AND AGRICULTURAL TYPOLOGY-REVIEW OF LITERATURE

The work of some distinguished geogrophare like Jonasson (1925), Baker (1926 & 1951), Stamp (1931), Whittlesey (1935), Weaver (1954), Birch (1954), Evans (1962), Chisholm (1962), Coppock (1964) and Kostrowicki (1964) and many others have provided an ample of informations to understand the types of studies conducted in the field of agricultural geography. These studies cover some of the important aspects from concepts, meanings, methodologies and types of agriculture at micro and macro levels.

Much attention has been paid to ascertain the direction for encountering the problems of land use in agriculture more effectively with applying the new techniques and methods evolved within the frame of geography. Prof. kostrowicki while working for the IGU commission evolved a scheme to analyse and differentiate the agricultural types to take studies for different regions of the workd.

While attempting to divide individual countries into agricultural regions. Jonasson (1925), took his study for the continent of Europe, and Baker (1926), for the North America. In their studies they emphasized the importance of market for the sale of agricultural products, and classified agriculture on the basis of cropping pattern and livestock grazing activities.

Whittlesey (1936), classified the world into major agricultural regions designating them with farming systems by using a uniform delimiting criteria, which facilitated to identify thirteen types of agriculture spreading over the world.

Deshpande, et al. (1959) in their study of chandrapuri valley emphasised the influence of physiographic features on the landuse and suggested an appropriate landuse planning at micro level.

Kawachi (1959), applied following three criterion for undertaking the world systems of agriculture:

i) Type of production

ii) Degree of commercialization

iii) Technical intensity

On the basis of above criterion, he identified eighteen types of agriculture in the world.

Otremba (1960), suggested another classification of agriculture with the methods of cultivation and kinds of organization. He attempted to distinguish the following main types of agriculture:

a) Individual enterprises whose purpose is to attain self-sufficiency

b) Individual enterprises whose purpose is to supply to commodities to the market.

c) Collective enterprises whose pusrose is to fulfil the national demands.

d) Cooperative enterprises with the orientation towards the world market.

Spancer and Horvath (1963), attempted to identify the importance of cultural aspects in the origin of agricultural regions more specifically with reference to psychological, political, historical, technological, economic and agronomic factors. He finds it logical to determine the regional typology based on the duration and characteristics of farming in the historical perspectives.

Kostrowicki (1964), introduced a preliminary scheme of agricultural typology for understanding the inherent characteristics and the tendencies in the changing spatial organization of agriculture in Poland. He selected three basic parameters namely, social and ownership, organizational and technical and economic features, to identify the world system of agriculture.

Mishra (1967), has attempted to divide the state of Rajasthan into 7 agricultural regions. This study provides a base for accounting the number of socio-economic activities of the people which are involved in them in the state.

Anderson (1970), classified the world's agriculture on the basis of four levels of frames: ecological, subsistence, commercial and collective farming systems. Singh (1976), in his study of Haryana state cash-cropping in addition to four levels of frames as adopted by Anderson recognised as the fifth level.

At the 8th meeting of IGU commission (1976) on agricultural typology several studies were reported for a number of regions and discussions were held. It was considered that the classification of agriculture should be made on the basis of its inherent characteristics. It was emphasized to classify agriculture on the basis of 4 attributes: social, operational production and structural.

Panda (1976), considered some of the indices as proposed by the IGU commission on agricultural typology while determining agricultural types in the state of Madhya Pradesh. The study identified three main types of

agriculture :

i) Subsistence agriculture

ii) Semi-subsistence agriculture

iii) Semi-commercial agriculture

Singh (1976), attempted to identify the typology of agriculture and examined in detail the problems of agriculture in the state of Haryana. Following the methodology initiated by the IGU commission on agricultural typology, he identified eight types of agriculture in the state.

Singh (1977), dealing with the taxonomy of typology of agriculture in the Indian context, he selected 22 variables and put them under four broad heads:

i) Social attributes

ii) Operational attributes

iii) Production attributes, and

iv) Structural attributes

Shafi (1981) considered the optimum use of land for agricultural production on the basis of the application of technology in different farming systems. According to him, there are two ways for increasing food production:

i) To increase the area under cultivation,

ii) To increase the output per person

Sharma (1983) applied the same procedures for the typological study as initiated by Prof. Kostrowicki in his study of Rajasthan state. The

state of Rajastan has been divided into agricultural regions of the order of : 3 first order types; 5 second order types; and 7 third order types.

Kostrowicki (1984), has presented a preliminary outline of the typology of European agriculture based on some 27 selected variables, and indentified six types of agriculture.

Galezynska (1984), attempted to study the agricultural typology of Bulgaria. This study concludes that the Bulgarian agriculture is indentified in the order of: 3 types of the 2nd order; and 6 types of the 3rd order.

Jedrusik (1992), in his empirical study adopted the concept, methods and procedures initiated by Prof. Kostrowicki for identifying in agricultural types in 16 small Tropical Islands. Taking into consideration various social, operational, production and structural attributes, he identified the characteristics of farming in order to make them comparable.

Sharma (1992), applied the same technique with a slight modification by selecting some areas from different states of India.

Stola (1992), studied the changes in agricultural landuse in Poland, in the historical prespective (1946-88). He studied the changes with reference to arable land, permanent grassland and perennial crops and agricultural patterns are systematically represented by the orientation of agricultural landuse.

Sundaram and Shanthi (1995), have studied the type of land utilization in Thandalam and Thevaram villages, Tamilnadu. The study

concludes that the nature and intensity of landuse depends upon the interaction of physical and socio-economic factors.

Nangraj et al. (1998), have studied the resource use efficiency in different crops under different farming systems in Tungabhadra command Area (Karnataka).

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Chapter III

LANDUSE AND CROPPING PATTERN IN GANGA-YAMUNA DOAB

A. Land use Pattern

Land use statistics provide the information of total geographical area into various uses. Since 1890-91, a five fold classification of the use of total geographical area was made and the land was put under the categories of land use classification :

i) Area under forests

ii) Area not available for cultivation

iii) Current fallows

iv) Net area sown

In 1949-50 the land classification was revised. A revised classification of land use has been accepted by all the states since 1950-51 which is still followed in the following form :

(i) Area under forests

(ii) Land which is not available for cultivation

  (a) Land put to non-agricultural uses

  (b) Barren land and uncultivated land

(iii) Culturable waste land

(iv) Other unculturable land excluding fallow land

  (a) Permanent pastures and other grazing lands

  (b) Miscellaneous tree crops and groves not included in net area sown

(v) Fallow land

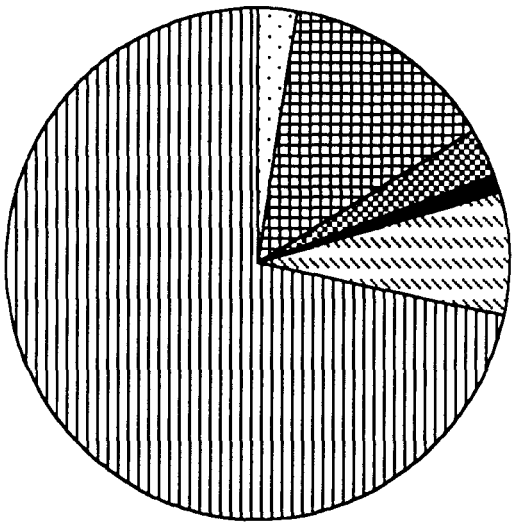
Table I

Land Utilization in Ganga-Yamuna Doab

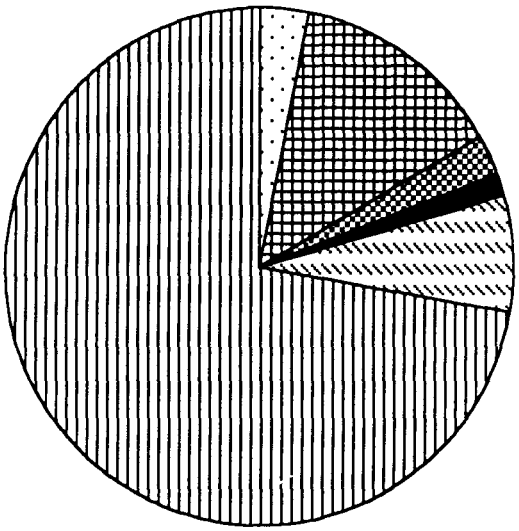
	Category	1990 to 1994		1995 to 1999	
		Area (in 000 ha.)	Area (in percentage)	Area (in 000 ha.)	Area (in percentage)
1.	Area under forests	166.17	2.61	193.30	3.00
2.	Land is not available for cultivation	874.92	13.74	870.71	13.54
(i)	Barren and uncultivable land	254.89	4.00	232.06	3.61
(ii)	Land put to non-agricultural uses	620.03	9.74	638.65	9.93
3.	Culturable waste land	188.82	2.96	175.95	2.74
4.	Other uncultivated land	77.90	1.23	76.87	1.15
(i)	Permanent pasture and grazing land	25.36	0.40	24.11	0.34
(ii)	Land under miscellaneous tree crops and groves	52.54	0.83	55.76	0.81
5.	Fallow land	488.70	7.67	477.33	7.42
(i)	Current fallows	247.26	3.88	252.52	3.93
(ii)	Others fallows	241.44	3.79	224.81	3.49
6.	Net Area sown	4572.21	71.79	4642.34	72.15
7.	Reporting Area	6368.72		6433.50	

Source : Office of Directorate of Agriculture, U.P., Lucknow.

LAND UTILIZATION IN GANGA-YAMUNA DOAB



1990-1994



1995-1999

- Area under forests
- Culturable waste land
- Fallow land
- Land is not available for cultivation
- Other uncultivated land
- Net Area sown

Fig. 3

(a) Fallow land other than current fallows

(b) Current fallows

(vi) Net area sown

(vii) Total reporting area

Figures relating to the land use classification for the Ganga-Yamuna Doab are given in Table I for two different periods of time i.e. 1990-94 and 1995-99.

Table I shows the total area of the region during 1990-94. It is seen from the table that there was 6368.72 thousand ha. as the reported area out of which 4572.21 thousand ha. (71.79 per cent) was net area sown. About 875 thousand ha. (13.74 per cent) were reported to be under the land not available for cultivation. There were 255 thousand ha. were categorised as barren lands, 620 thousand ha. as non-agricultural land of the total area and the other uncultivated land excluding fallow land and groves about 78 thousand ha. (1.23 per cent). The waste land accounted for about 188 thousand ha. (3 per cent). The remaining 488.7 thousand ha. (8 per cent) of the total area was left as fallow lands.

During 1995-99 the reporting area for land utilization purposes was estimated to be 6433.50 thousand ha., out of which 4642.34 thousand ha. (72 per cent) reported as the net area sown. The area covered under forests reported to be 193.30 thousand ha. (3 per cent). Land put to non-agricultural uses accounted for 870.71 thousand ha. (13.54 per cent). Culturable waste land covered 175.95 thousand ha. (2.74 per cent). The area under fallow lands (including current and other fallows) was 477.33 thousand ha. (7.42 per cent). The remaining area under the permanant pastures and grazing lands and land

under miscellaneous tree crops and groves accounted for as 76.87 thousand ha. (1.15 per cent).

A comparative study of land use in the Doab region for the period 1990-94 and 1995-99 shows, that there is a continuous change in reporting area for the land use purposes, which shows an additional increase of 74.80 thousand ha. (1.02 per cent). The net area sown accounted for an increase of 64.13 thousand ha. (1 pm8. ur cent). The area under forests has also increased to the extent of 27.13 thousand ha. (16.51 per cent). There is a decline in area under barren and un-cultivable land amounting to 22.83 thousand ha., and the land put to non-agricultural use shows an increase of 18.62 thousand ha. in between 1990-94 and 1995-99.

Besides this in some other categories of such as culturable waste land shows more or less a declining trend in area. This may have been due to the reorientation of land use and management practices, resulting in the intensive use of land.

B. Cropping Pattern

Cropping pattern refers to the proportion of area devoted to cultivation for a number of crops at a given point of time. The cropping pattern differs from micro to macro areas both in space and time, and is governed largely by a number of physical, cultural and technological factors.

To deal with cropping pattern and levels of production in the Ganga-Yamuna Doab. It would be worthwhile to give a preliminary idea about the sowing and harvesting seasons of major crops in the region.

There are two main agricultural seasons in the region

(i) *Kharif* or the summer crop season

(ii) *Rabi* or the winter crop season

The sowing of crops in the *Kharif* season begins generally with the onset of southwest monson in mid-June, while the *rabi* season begins with the begining of the cold weather i.e. by the end of the month of October or early November. The important crops sown in the *Kahrif* season are: rice, jawar, bajra, maize, arhar, moong, urad, groundnut and sugarcane, which requires a high temperature and plentiful supply of water, and the crops grown in *rabi* season are: wheat, barley, gram, masur, peas and potatoes which requires low temperatures and moderate amount of moisture. The harvesting of *kharif* crops starts by the end of monsoon i.e. from the months of September to October, and the *rabi* crops are harvested during the months of March to April.

Crop land use and production of crops

As the study is based on some selected food crops, therefore, it is needed to examine their relative position with respect to area, production and yield.

Table II shows a trend of growth of each crop with respect of area, production and yield during the periods of 1990-94 and 1995-99 in the Ganga-Yamuna Doad region. It is quite clear from Table II, that there exists little possibility for the increase in area under different crops.

The average area under food grains for the region was 5038.4 thousand ha. (80.49 per cent) in 1990-94. During the period 1995-99, the area

Table II

Estimates of Area, Production and Yield of Crops in Ganga-Yamuna Doab

Crops	1990 to 1994			1995 to 1999			% change	% change
	A	P	Y	A	P	Y	in A	in P
Rice	640.36	1202.27	18.78	750.37	1528.75	20.37	+1.72	+27.16
Wheat	2569.77	6488.58	25.25	2437.29	7528.81	30.89	-5.16	+16.03
Maize	472.09	769.52	16.30	434.87	777.90	17.89	-7.88	+1.09
Jowar	98.79	111.25	11.26	95.42	98.05	10.28	-3.41	-11.87
Bajra	503.00	599.88	11.93	551.55	775.84	14.07	+9.65	+29.33
Barley	206.22	486.67	23.60	177.34	480.91	27.12	-14.00	-1.18
Gram	247.22	283.58	11.47	208.42	216.20	10.37	-15.69	-23.76
Peas	89.39	140.62	15.73	65.05	102.62	15.78	-27.23	-27.02
Arhar	162.45	212.06	13.05	136.93	183.43	13.40	-15.72	-13.50
Others Pulses	49.11	28.60	5.83	43.00	26.81	6.23	-12.44	-6.26
Oilseeds	525.54	534.57	10.17	463.22	480.76	10.38	-11.74	-10.07
Sugarcane	529.67	33136.88	625.62	562.93	36319.88	645.19	+6.28	+9.61
Potato	166.22	3309.83	199.12	185.57	4638.47	249.97	+11.64	+40.14

Area - in 000 hectares, Production - in 000 metric tonnes, Yield - quintals/hectare

Source : Office of Directorate of Agriculture, U.P., Lucknow.

Table III

Area under major crops in the Ganga-Yamuna Doad

Crops.	1990 to 94		1995 to 99	
	Area (in 000 ha.)	(in Percentage)	Area (in 000 ha.)	(in Percentage)
Foodgrains	5038.40	80.49	4900.24	80.17
Cereals	4490.23	89.12	4446.84	90.75
Pulses	548.17	10.88	453.40	9.25
Oilseeds	525.54	8.39	463.22	7.58
Cashcrops	695.89	11.12	748.50	12.25
Sugercane	529.67	76.11	532.93	75.21
Potato	166.22	23.89	185.57	24.79

Source : Office of Directorate of Agriculture, U.P., Lucknow.

under foodgrains accounted for 4900.24 thousand ha. (80.17 per cent). It is seen from Table III, that there has been a decline in area under foodgrains to the tune of 138 thousand ha. in 1995-99, as compared to the period 1990-94. One of the main reasons of this decline in area seems to be due to a shift of area from foodgrains to the cultivation of cash crops. In case of oilseeds there is also a variation in area devoted to them. During 1990-94, oilseeds were cultivated over the area of 525.54 thousand ha. (7.58 per cent). The cash crops show an increase in area to the extent of 748.50 thousand ha. (12.25 per cent) during 1995-99 as compared to 695.89 thousand ha. (11.12 per cents) in 1990-94.

Among the individual crops rice, bajra, sugarcane, potato show an increasing trends in area devoted to these crops. Rice recorded a change accounted for 640.36 thousand ha. in 1990-94 and 750.37 thousand ha. in 1995-99. Bajra recorded an increase in area to about 49 thousand ha. next to the rice during 1995-99. Next to rice and bajra, sugercane and potato show a gradual increase in area.The area devoted to sugercane was 562.93 thousand ha. (75.21 per cent) in 1995-99, while it was 529.67 thousand ha. in 1990-94. potatoes covered an area of 166.22 thousand ha. in 1990-94 and which increased to the tune of 19.35 thousand ha. in 1995-99.

As regards the production of individual crops the situation has been well encouraging. rice, wheat, sugarcane, and potatoes, constituted a share of about 93 per cent in 1990-94 and 94 per cent in 1995-99, in gross crop production in the Ganga-Yamuna Doab. In wheat, rice and sugercane, the achievements in crop output are well marked. It is evident from Table III, that wheat was cultivated on 2569.77 thousand ha. in 1990-94 which accounted a

production of 6488.58 thousand tonnes with an average yield of 25.25 qnts/ ha. During 1995.99 wheat was cultivated over an area of 2437.29 thousand ha., which accounted for a production of 7528.81 thousand tonnes and the yield per hectare increased to 39.89 qnts./ha. Rice recorded a production of 1202.27 thousand tonnes, with an average yield of 18.78 qnts./ha. and covered an area of 640.36 thousand ha. in 1990-94. During 1995-99 rice occupied an area of 750.37 thousand ha. The crop production in 1995-99 gone upto 1528.75 thousand tonnes with an average yield of 20.37 qnts./ha.

Among the cash crops sugarcane and potatoes also show an increase in area and production in the Doab. During the period 1990-94, sugarcane, accounted for an area of 529.67 thousand ha. and the production was recorded 33136.88 thousand tonnes with an average yield of 625.62 qnts./ha. The area under sugarcane increased 562.93 thousand ha. during the period 1995-99 and the gross output accounted for 36319.88 thousand tonnes with an average yield of 645.19 qnts./ha. Potatoes were cultivated on 166.22 thousand ha. in 1990-94, which recorded a gross production of 3309.83 thousand tonnes with an average yield of 199.12 qnts./ha. During 1995-99, the area under potatoes increased to 185.57 thousand ha. and output accounted for 4638.47 thousand tonnes, with an average yield of 249.97 qnts./ha.. The others crops grown in the region show a gradual decrease in area and an increase in the gross production. Among other crops, gram covered an area of 247.22 thousand ha. to produce 283.58 thousand tonnes with an average yield of 11.47 qnts/ha. in 1990-94. In 1995-99, gram occupied 208.42 thousand ha., recorded a decrease of 38.8 thousand ha. as compared to the previous period, with an average yield of 10.37 qnts./ha..The

area and production of oilseeds show a decrease during the period of 1995-99. The decline recorded to the extent of 463.22 thousand ha. in 1995-99 while in 1990-94, it was cultivated over an area of 525.54 thousand ha., whereas, the production was 534.57 thousand tonnes in 1990-94, and 480.76 thousand tonnes in 1995-99. Although the average yields were identical to the tune of 10 qnts./ha. in both the periods.

Pattern of Crop-Combinations

For the study of crop-association and crop-combination a number of statistical methods have been devised. In order to mark out the crop-combination regions in the Ganga-Yamuna Doab, Doi's method was applied, which substitutes Weaver's method of $\Sigma d^2/n$ with the sum of square differences Σd^2. The combination having the smallest Σd^2 will be the combination of primary crops. It is not required to calculate Σd^2 for each combination but it can be found by only consulting a one-sheet table which Doi himself has provided. The table presents the critical values for different elements at vairous accumualted percentages. Instead of squaring the differences, it is required to sum up the percentages and then consult the table for the critical value of the next element at that accumulated percentage level. If the critical value is higher than the actual value of the percentage, the crop is not considered, but if otherwise the value is lower than the crop percentage, the crop is included in the combination. To illustrate the statistical procedure of the crop-combination the district of Aligarh may be cited as an example; individual crop landuse percentages in Aligarh during 1990-94 are given below : W - 42.57, B - 16.60, O - 11.95, M - 8.14, By - 6.98, S - 2.31, R - 2.30, Pe - 1.99

W = wheat, G = Gram, B = Bajra, R = Rice, M = Maize, A = Arhar, J = Jowar, By = Barley, Pl = Pulses, S = Sugarcane, Po = Potato, Pe = Peas and O = Oilseeds

Monoculture = $(100-42.57)^2 = 3298.20$

Two crop = $(50-42.57)^2 + (50-16.69)^2 = 1170.76$

Three crop = $(33.33-42.57)^2 + (33.33-16.60)^2 + (33.33-11.95)^2$

= 822.37

Four crop = $(25-42.57)^2 + (25-16.60)^2 + (25-11.95)^2 + (25-8.14)^2$

= 833.83

Five crop = $(20-42.57)^2 + (20-16.60)^2 + (20-11.95)^2 + (20-8.14)^2 +$ $(20-6.98) = 895.95$

From the above calculation the minimum deviation value is 822.37. Therefore three corps (wheat, bajra and oilseed) are major crops in Aligarh.

Crop-Combination Regions

Crop-combination regions in the Doab based on Doi's method were worked out for two distinct periods 1990-94 and 1995-99. It will be seen from Figs. 4 & 5 that during the period 1990-94 crop-combination range, from 2 to 5 crops in all the districts. A lowest combination consisting 2 crops only predominates in five districts of Muzaffarnagar, Meerut, Bulandshahr, Kanpur Nagar and Allahabad. Three crop-combination were found dominating in eight districts namely, Ghaziabad, Aligarh, Mathura, Agra, Firozabad, Mainpuri, Etah and Fatehpur. In these districts wheat was the common crop in the combination. A four crop-combination was existed only in one district of Etawah. In remaining two districts of Farrukhabad and Kanpur Dehat there were five crop-combinations.

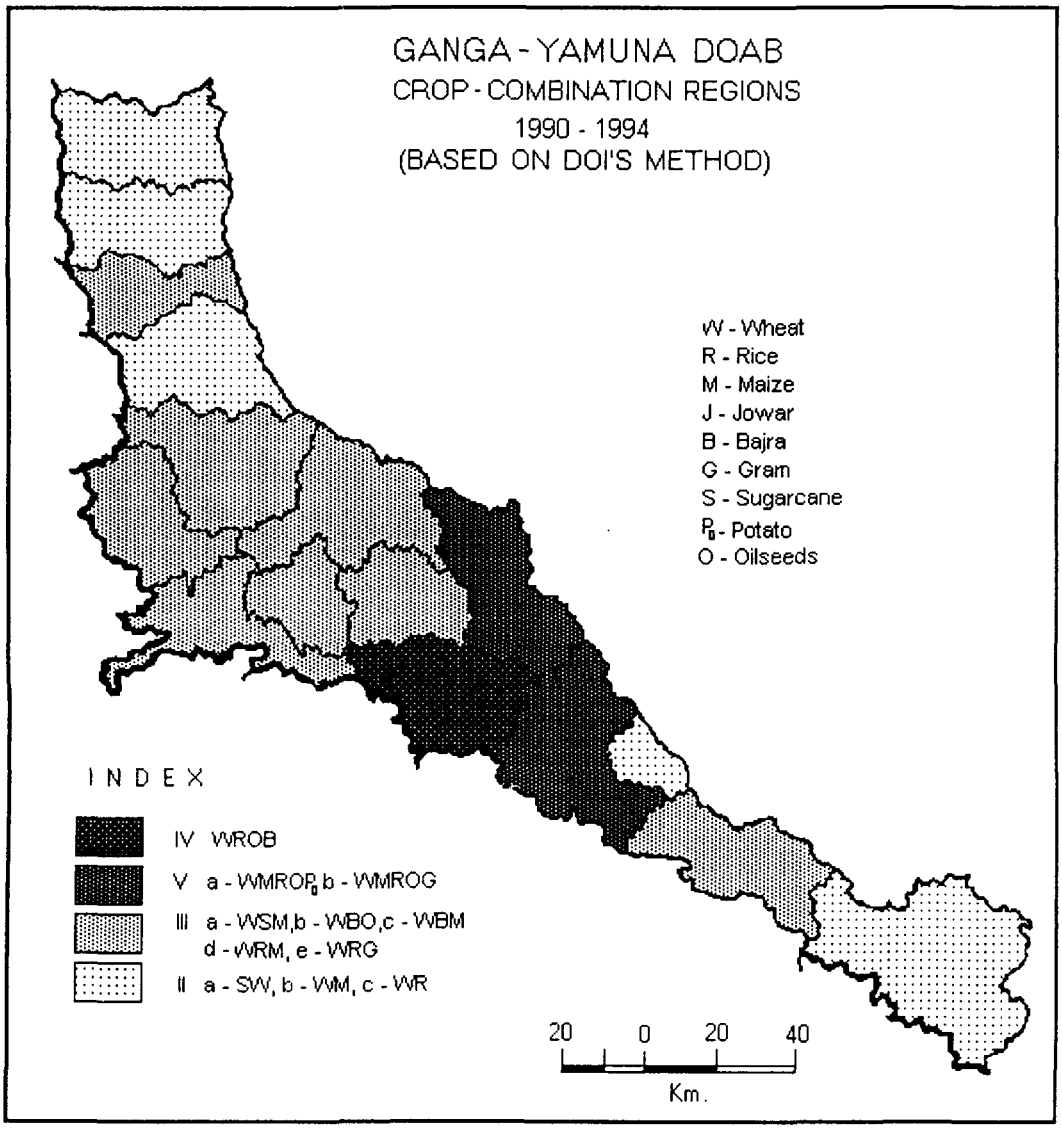

GANGA - YAMUNA DOAB
CROP - COMBINATION REGIONS
1990 - 1994
(BASED ON DOI'S METHOD)
W - Wheat
R - Rice
M - Maize
J - Jowar
B - Bajra
G - Gram
S - Sugarcane
P - Potato
O - Oilseeds
INDEX
IV WROB
V a - WMROP b - WMROG
III a - WSM,b - WBO,c - WBM
d - WRM, e - WRG
II a - SW, b - WM, c - WR
20 0 20 40
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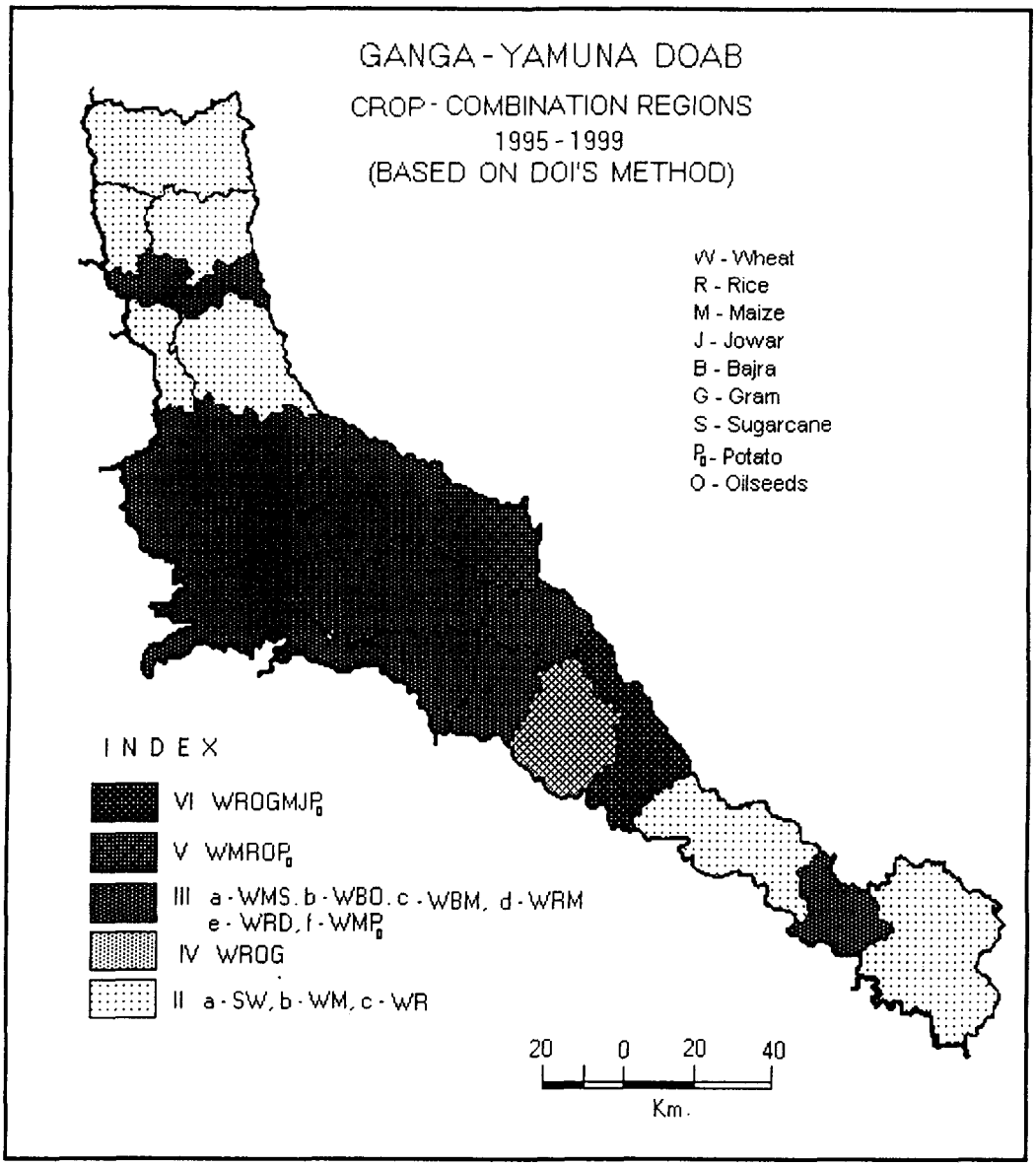
Fig. 4


GANGA - YAMUNA DOAB
CROP - COMBINATION REGIONS
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W - Wheat
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B - Bajra
G - Gram
S - Sugarcane
P - Potato
O - Oilseeds
INDEX
VI WROGMJP
V WMROP
III a - WMS, b - WBO, c - WBM, d - WRM
e - WRD, f - WMP
IV WROG
II a - SW, b - WM, c - WR
20 0 20 40
Km.

Fig. 5

During the period 1995-99 crop-combination range, from 2 to 6 crops in the region. Two crop combination existed in seven districts namely, Muzaffarnagar, Baghpat, Meerut, Bulandshahr, Gauthambudha Nagar, Farrukhabad and Allahabad. Three crops-comnbination was predominant in twelve districts of Ghaziabad, Aligarh, Hathras, Mathura, Agra, Firozabad, Mainpuri, Etah, Etawah, Kannauj Auraiya and Kushambi. Four and five crop-combination was found in the districts of Kanpur Dehat and Farrukhabad. The district of Kanpur Nagar shows six crop-combination.

C. Irrigation and Land Use

The Ganga-Yamuna doab is one of the intensively irrigated region in the state of Uttar Pradesh, and therefore, irrigation has played a dominent role in increasing the quantum of crop production and productivity per hectare during the last few decades. About 80 per cent of the cropped area is under irrigation and a major portion of irrigation is provided by underground source of water, and only a small cropped area receives irrigation from surface supplies mainly from canals.

There are three main sources of irrigation in the Doab :

1. Irrigation by canals
2. Irrigation by Tube-wells
3. Irrigation by well and other sources.

1. Canal commands more than half of the irrigated area of the Doab. There are three important canals providing irrigation in the Doab :

i) The Upper Ganga canal

ii) The Lower Ganga canal

iii) The Eastern Yamuna Canal

i) The Upper Ganga Canal

This canal was opened on 8th April 1854 but irrigation by it was possible to provide irrigation waters by May 1856. The Upper Ganga canal has a length of about 342 km. and it has four main branches. The area irrigated by this canal is over a million hectares, covering the districts of Muzaffarnagar, Meerut, Mathura, and Etah. It has two important branches :

a) The Mathura branch and

b) The Hathras branch

ii) The Lower Ganga Canal

It takes off waters from the Narora and irrigates over a million of hectares. There are five important branches of this canal. The water of these branches provide irrigation to the agricultural lands in the districts of Bulandshahr, Aligarh, Etah, Mainpuri, Fatehpur, Kanpur and Allahabad.

iii) The Eastern Yamuna Canal

It takes off waters from the right bank of the river Yamuna and provides irrigation to the districts of Muzaffarnagar and Meerut.

2. Tube-well Irrigation

Tube-well and well predominent in the upper Doab, districts of Muzaffarnagar, Bulandshahr, Ghaziabad, and in districts forming lower Doab, namely, Farrukhabad, Etawah, Kanpur Nagar, Kanpur Dehat, Auraiya, Kannauj and Allahabad. The economic effects of irrigation by Canals and

Table IV

Source Wise Net Irrigated Area in Ganga-Yamuna Doab

Source	Period 1990 to 94		Period 1995 to 99	
	Area (in 000 ha.)	(In Percentage)	Area (in 000 ha.)	(In Percentage)
Canal	1132.99	30.36	1039.26	26.78
Tube-wells	2520.47	67.55	2707.99	69.79
Wells	48.05	1.29	92.73	2.39
Tanks. Lakes & Ponds	5.80	0.15	4.09	0.11
Others	24.18	0.65	36.27	0.93
Net Irrigated Area	3731.50		3880.34	

Source : Office of Directorate of Agriculture, U.P., Lucknow.

wells on the levels of agricultural production and the patterns of cropland use and occupation of the people are of considerable importance in the Doab. Increased irrigation facilities have helped the cultivation not only in increasing the area under cultivation but also in increasing the output per hectare. The two cash crops sugarcane and potatoes entirely depend on irrigation in the Doab.

It is evident from Table IV, that the net irrigated area during 1990-94 was 3731.50 thousand ha., out of which 1132.99 thousand ha. (36.36 per cent) was irrigated by canals. The largest share of irrigated area by canals was between 30 and 60 per cent to cover the districts of Muzaffarnagar, Mathura, Mainpuri, Etawah, Kanpur Dehat, Fatehpur and Allahabad.

It is further seen from Table IV that there is an increase in net irrigated area during 1995-99. The total area was accounted for 3880.34, which shows an increase of 151 thousand ha. as compared to 1990-94. But it also shows a decline in area irrigated by canals. In 1995-99, the total irrigated area was 1039 thousand ha. (26.78 per cent) which declined to 93 thousand ha., as compared to the figures during 1990-94.

Irrigation by tube-wells forms a great importance in Doab. The importance of tube-well irrigation over canals lies because of, it can be constructed right in the centre of the place where water is needed for crops . During the period 1990-94, the area under tube-wells irrigation was 2520.47 thousand ha. (67.55 per cent) of the net irrigated area 3731.51 thousand ha.. All of the districts have a share of area irrigated by tube-well between 40 to 86 per cent. During the period 1995-99, the area irrigated by tube-wells

accounted for 2707.90 thousand ha. (69.79 per cent), an increase of 187.52 thousand ha., as compared to the period 1990-94. The intensity of irrigation by tube-wells in all the districts ranges between 40 to 90 per cent.

The other sources of irrigation constitute, wells, tanks and ponds. In areas where canal and tube-wells irrigation show inadequacy to provide water for irrigation, other sources provide water as the supplement to the requirements. During the period 1995-99, the area irrigated by other sources was 133 thousand ha. (3.4 per cent) and 78 thousand ha (2 per cent) in 1990-94.

CHAPTER IV

AGRICULTURAL PRODUCTIVITY AND ITS DETERMINANTS

A. The Concept of Agricultural Productivity

A number of researcher working in different disciplines have attempted to define the term Agricultural productivity. A good number of geographers, economists and agricultural scientist have attempted to define agricultural productivity.

The term productivity relates to yield per unit area of cultivated land. Agricultural productivity is not synonymous of 'fertility', it signifies the capability of soil which provides nutrients to the plant and helps in its growth. Technically agricultural productivity can be considered as an expression of the art of securing an increase in output from the inputs or of getting the same output from a smaller amount of inputs. Productivity of agriculture can also be considered as the output per unit of input.

Several scholars have attempted to define productivity on different bases. According to Kendrick, "the story of productivity, the ratio of output to input, is at the heart of man's effort to raise himself from poverty." The other way to define the term productivity is that it is the relationship in physical terms between input and output. In a broader sense, it signifies the ratio of index of total agricultural output to the index of total input applied in farm production. It is therefore, a measure of the efficiency with which inputs are utilized in production, other things being equal. Dewett, defines it that "productivity expresses the varying relationship between agricultural output and one of the major inputs (like land, labour and capital), other

complementary factors remaining the same."

It should, however be kept in the mind, that productivity is a physical term rather than a value concept and signifies a changing relationship between output and one of the major inputs like land, labour and capital. According to Saxon, "productivity is a physical relationship between the output and the input which gives rise to output." Horring defines it as that, "productivity is generally used, rather broadly to denote the ratio of output to any or all associated inputs in real term."

The International Commission on Agricultural Typology seized on this problem, and the Chairman of the commission Prof. Kostrowicki, invited different views on this by sending a questionnaire to over hundred scholars all over the world which embodied the following two questions :

1) What methods of measuring intensity of agriculture should be applied in typological studies of various orders?

2) What methods, measuring and indices should be use to define land, labour, and capital productivity of agriculture in typological studies of various orders?

About fifty geographers from all over the world responded and suggested various approaches to the measurement of agricultural productivity and intensity. The chairman of the commission, while commenting on different views pointed out, that a special study for testing various methods and techniques to be used in studies of various scales were needed.

Agricultural productivity so far has been considered from various points of view e.g. productivity of land, labour and capital. These are known

to be the partial productivity measures.

a) Land Productivity

As far as the productivity of land is considered it may specially be considered for meeting of the food demands of increasing population. To keep pace with the demand of food for growing population, it is essential to achieve an immediate increase production per unit area both in terms of money and caloric value. From national point of view, it is desireable to secure the employment to the greatest number of persons.

Productivity of land is dependent on certain natural factors like temperature, rainfall and soil in association with many socio-economic and technological factors.

b) Labour Productivity

The measurement of labour productivity in agriculture is more complex than land productivity. It may be considered in terms of working hours needed to produce a quantum of crop output. Labour productivity is usually considered to account for the contribution of the population engaged to get output per unit of labour. Labour productivity is computed by taking into consideration the average yield per hectare of land and the number of workers employed. It simply takes the following form :

Labour productivity = Net output/Number of workers

c) Capital Productivity

The capital productivity measures are equally complicated for the amount of capital spent on various operations and purchase of a number of inputs in agricultural e.g. the fertilizer, irrigation, land reclamation, purchase

of modern agricultural implements and machinary and for several others purposes.

B. Agricultural Productivity and its Determinants

An attempt has been made to measure the crop productivity in the districts of Doab region. For this purpose the crops considered, were put into different groups as cereals, pulses, oilseeds and cash crops and taking into consideration all the crops. An aggregate productivity was computed by applying the method devised by W.Y.Yang (1965). He initiated 'Crop Yield Index' method to measure productivity of a farm by considering the yield per hectare of the crop concerned and the magnitude of area devoted to the crop in the region.

Before calculating the crop yield index on a particular farm, the average yield of each of the crop grown in the region must be determined. Then by dividing the yield of the crop in the region, a percentage figure is obtained which when multiplied by 100 which gives the index number, as show in Table V, column 5. By incorporating the area devoted to each crop as a weight and multiply this percentage index, the products is obtained which is shown in column 6 of Table V. By adding the products and dividing the sum of the products by the total area of crops on the farm (the sum of column 4), the average index is the desired crop index for the particular farm using, crop area as weight.

This gives an index of crop yield which measures productivity of a farm with reference to the yield of entire region. The productivity index may be computed by taking into account major crops grown in the study area. The Yang's 'Crop Yield Index' method can be illustrated by taking district Aligarh of the Doab as an example.

Table V

Name of Crop	Yield (qnts/ha.)		Area of crop in the Districet	Crop yield in District as per-centage of the State	Percentage multiplied area in ha.
	Average yield in region	Yield in the District		$\frac{\text{Col 3}}{\text{Col 2}} \times 100$	Col 4 x Col5
1	2	3	4	5	6
Rice	18.73	17.83	124.50	94.94	11820.03
Wheat	25.25	27.47	2304.01	108.79	250653.25
Maize	16.30	17.64	440.28	108.22	47647.10
Jowar	11.26	7.25	6.29	64.39	405.01
Bajra	11.94	12.62	898.49	105.70	94970.39
Barley	23.60	27.23	377.93	115.38	43605.56
			4151.50		449101.34

Computation of crop yield index for the district of Aligarh $= \frac{449101.34}{4151.50} = 108.18$ Per cent

A. Crop Productivity Regions in Ganga-Yamuna Doab

a) Productivity Regions : Based on cereal crops - 1990-94 and 1995-99

The crop productivity computed of cereal crops for the period 1990-94 is shown in Table VI. It is seen from the table, that productivity indices vary from a lowest index value of 87.05 for the district of Allahabad to a maximum index value of 132.85 for the district of Meerut. Infact only three districts namely, Meerut, Muzaffarnagar and Mathura form a high productivity region. The areas with medium productivity ranging from 105 to 125 cover the districts of Bulandshahr, Agra, Ghaziabad, Mainpuri, Aligarh, Etawah and Kanpur Dehat.

The areas under low productivity with the index value ranging from 85 to 105, include the districts of Firozabad, Farrukhabad, Etah, Kanpur Nagar, Fatehpur and Allahabad. Most of these districts are concentrated in lower Doab. It is therefore, seen that the productivity in the cereal crops decreases in the districts from upper to lower Doab.

As shown in Table VII that during 1995-99, the productivity ranges from a lowest index value of 79.04 for the district of Allahabad to a maximum value of 126.25 for the district of Muzaffarnagar. There are four districts of Muzaffarnagar, Baghpat, Kannauj and Hathras, having high productivity, with index value of ranging from 115 to 135 per cent (Table VIII). The medium productivity ranging between an index value from 95 and 115 to consist of 14 districts of the Doab. The remaining 4 districts namely, Kanpur Nagar, Fatehpur, Kaushambi and Allahabad are marked with low productivity, with the index value ranging from 75 to 95 per cent.

Table VI

The Ganga-Yamuna Doab - Crop Yield Index 1990-94

(Based on Yang's method)

Creals		Pulses		Oilseeds		Cashcrops		Composite	
District	Index	District	Index	District	Index	District	Index	District	Index
Meerut	132.85	Kanpur Dehat	115.73	Agra	112.59	Agra	113.44	Agra	113.27
Muzaffarnagar	126.60	Kanpur Nagar	113.31	Ghaziabad	108.14	Firozabad	113.01	Meerut	111.41
Mathura	125.39	Etawah	107.24	Etawah	106.98	Balandshahr	111.03	Mazaffarnagar	108.96
Bulandshahr	122.30	Agra	106.96	Firozabad	101.97	Muzaffarnagar	108.77	Bulandshahr	105.09
Agra	120.04	Fatehpur	105.73	Mathura	100.30	Mainpuri	105.50	Firozabad	102.73
Ghaziabad	118.84	Muzaffarnagar	102.81	Muzaffarnagar	97.64	Ghaziabad	103.73	Ghaziabad	102.22
Mainpuri	116.32	Allahabad	102.36	Meerut	97.64	Meerut	100.64	Etawah	101.39
Aligarh	108.18	Etah	99.75	Bulandshahr	96.46	Farrukhabad	97.29	Kanpur Dehat	101.33
Etawah	107.85	Mainpuri	95.63	Kanpur Nagar	96.36	Aligarh	95.39	Mainpuri	101.28
Kanpur Dehat	106.78	Ghaziabad	95.16	Farrukhabad	96.17	Mathura	92.63	Mathura	100.51
Firozabad	104.23	Meerut	93.48	Kanpur Dehat	95.08	Kanpur Dehat	87.74	Kanpur Dehat	96.78
Farrukhabad	102.50	Firozabad	91.72	Aligarh	91.94	Allahabad	85.46	Farrukhabad	95.68
Etah	97.10	Bulandshahr	90.57	Etah	91.94	Etah	83.71	Aligarh	95.21
Kanpur Nagar	95.82	Farrukhabad	86.74	Mainpuri	87.70	Kanpur Nagar	83.61	Etah	93.13
Fatehpur	87.45	Aligarh	85.34	Fatehpur	70.99	Etawah	83.48	Fatehpur	84.89
Allahabad	87.05	Mathura	83.70	Allahabad	48.09	Fatehpur	75.88	Allahabad	80.74

Table VII

The Ganga-Yamuna Doab - Crop Yield Index 1995-99

(Based on Yang's Method)

Creals		Pulses		Oilseeds		Cashcrops		Composite	
District	Index	District	Index	District	Index	District	Index	District	Index
Muzaffarnagar	126.25	Kaushambi	159.48	Gautambudhnagar	168.75	Agra	122.10	Auraiya	118.86
Baghpat	123.06	Kanpur Nagar	128.90	Baghpat	166.70	Hathras	11.58	Baghpat	116.42
Kannauj	115.92	Auraiya	118.73	Auraiya	157.55	Firozabad	105.06	Agra	115.49
Hathras	115.50	Agra	115.00	Hathras	148.98	Baghpat	104.50	Gautambudhnagar	105.91
Auraiya	114.09	Etawah	113.00	Kannauj	145.38	Muzaffarnagar	104.43	Muzaffarnagar	105.59
Meerut	113.92	Kanpur Dehat	111.40	Agra	116.67	Meerut	100.36	Hathras	104.98
Gautambudhnagar	112.97	Kannauj	104.95	Etawah	109.75	Auraiya	99.77	Etawah	103.66
Bulandshahr	110.03	Fatehpur	102.73	Aligarh	106.84	Ghaziabad	99.18	Kannauj	101.15
Agra	108.20	Muzaffarnagar	102.15	Firozabad	100.77	Gautambudhnagar	99.10	Kanpur Dehat	99.83
Ghaziabad	105.93	Farrukhabad	97.18	Meerut	98.36	Farrukhabad	96.53	Farrukhabad	98.27
Farrukhabad	105.14	Allahabad	96.09	Ghaziabad	98.36	Aligarh	95.35	Firozabad	97.97
Aligarh	102.97	Etah	88.29	Kanpur Dehat	97.30	Bulandshahr	94.72	Meerut	97.75
Etawah	102.54	Baghpat	86.52	Farrukhabad	94.22	Mathura	93.54	Kanpur Nagar	93.73
Firozabad	100.13	Firozabad	85.90	Mathura	91.14	Kanpur Dehat	90.85	Aligarh	93.39
Kanpur Dehat	99.78	Mainpuri	84.62	Etah	89.79	Etawah	89.00	Ghaziabad	92.36
Etah	97.64	Meerut	78.36	Muzaffarnagar	89.51	Mainpuri	86.89	Kaushambi	91.82
Mathura	95.65	Aligarh	68.38	Mainpuri	85.36	Allahabad	80.39	Etah	88.91
Mainpuri	95.20	Hathras	67.99	Bulandshahr	78.42	Etah	79.89	Mainpuri	88.89
Kanpur Nagar	91.58	Mathura	66.33	Kanpur Nagar	75.63	Fatehpur	79.75	Mathura	88.15
Fatehpur	81.62	Ghaziabad	65.95	Kaushambi	72.54	Kanpur Nagar	78.79	Bulandshahr	85.99
Kaushambi	80.04	Bulandshahr	60.60	Fatehpur	61.95	Kaushambi	67.53	Fatehpur	81.51
Allahabad	79.04	Gautambudhnagar	56.40	Allahabad	51.83	Kannauj	65.43	Allahabad	76.84

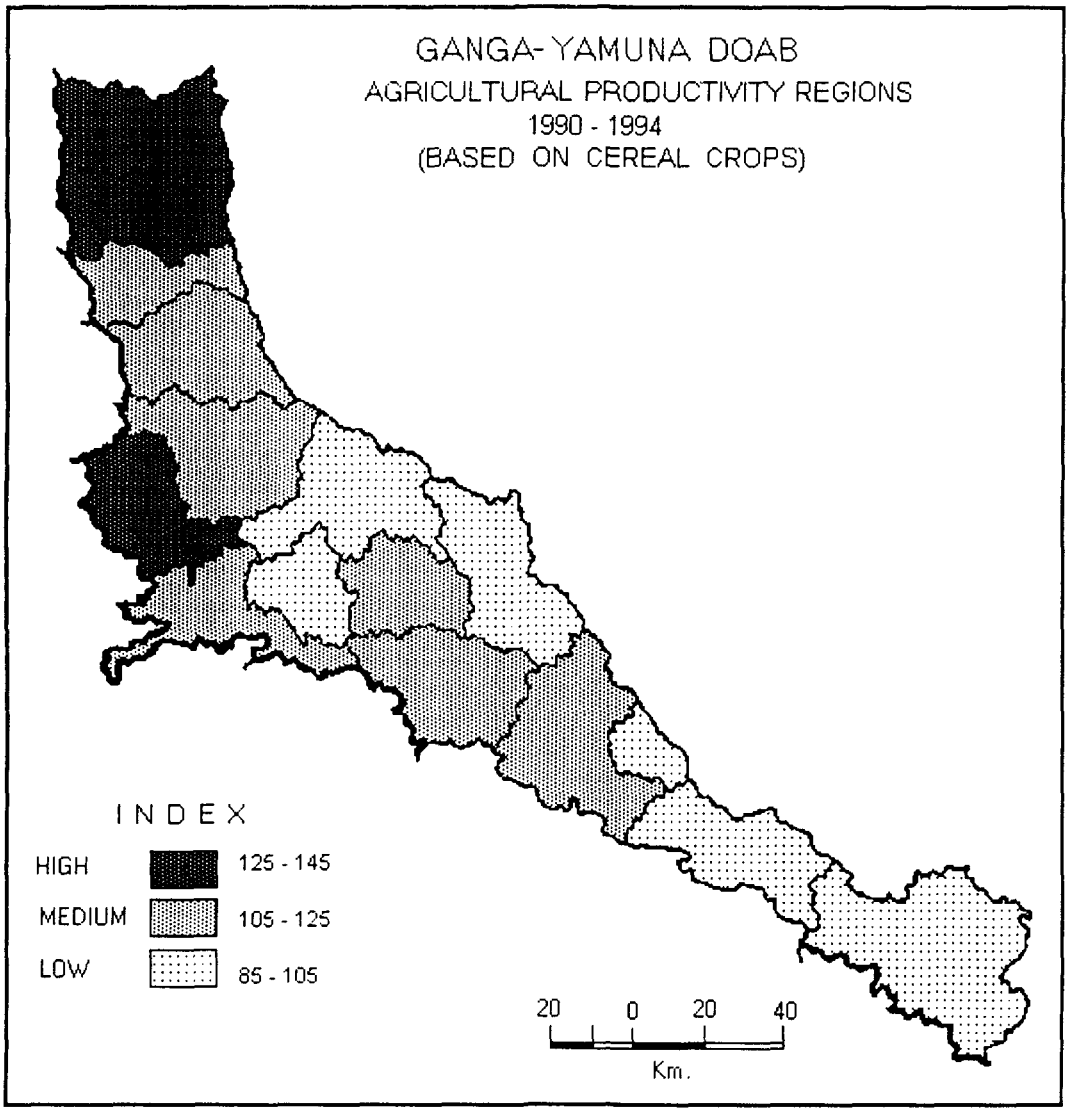
GANGA-YAMUNA DOAB
AGRICULTURAL PRODUCTIVITY REGIONS
1990 - 1994
(BASED ON CEREAL CROPS)
INDEX
HIGH
125 - 145
MEDIUM
105 - 125
LOW
85 - 105
20 0 20 40
Km.

Fig. 6

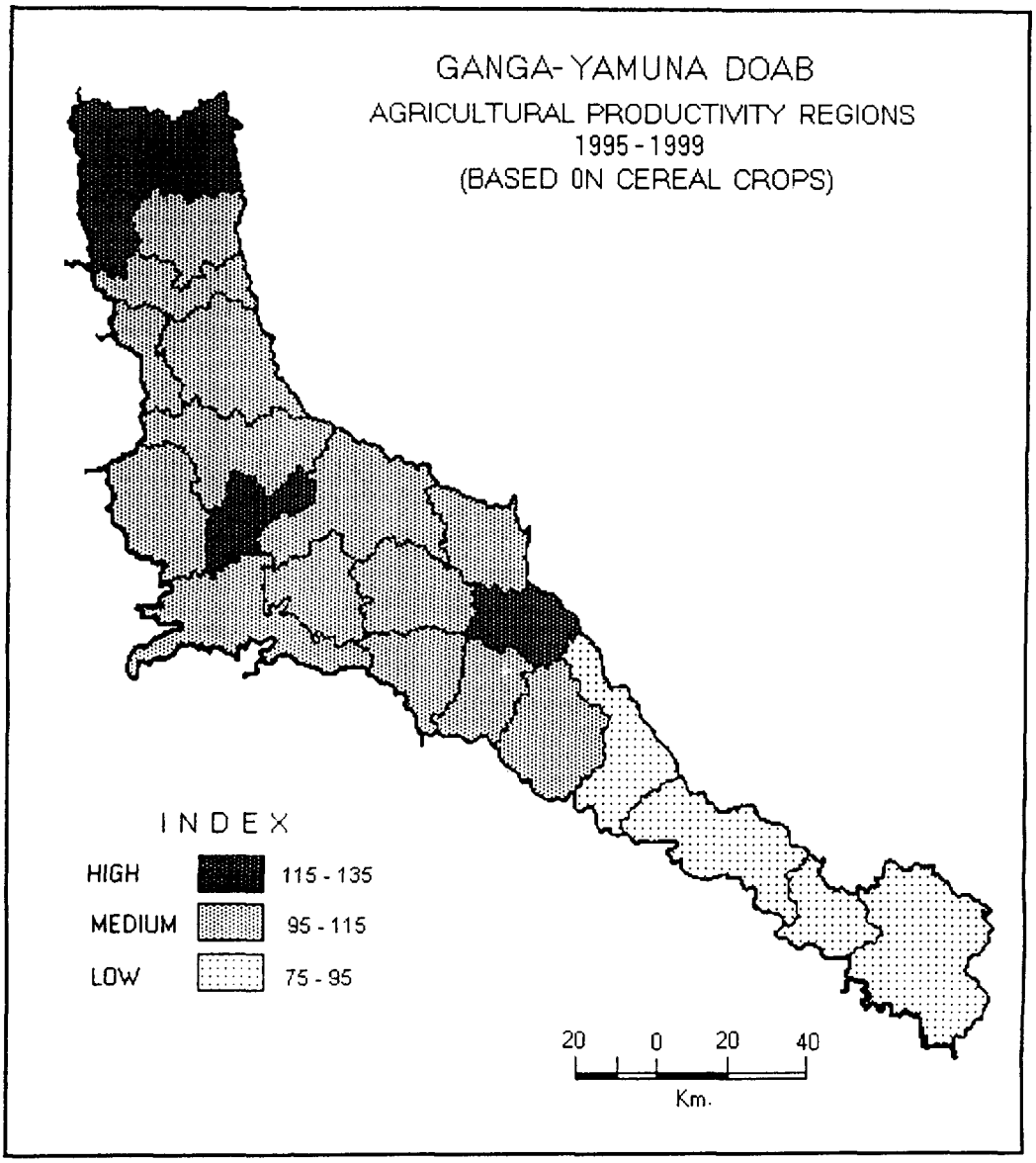
GANGA-YAMUNA DOAB
AGRICULTURAL PRODUCTIVITY REGIONS
1995-1999
(BASED ON CEREAL CROPS)
INDEX
HIGH
115 - 135
MEDIUM
95 - 115
LOW
75 - 95
20 0 20 40
Km.

Fig. 7

b. Productivity Regions : Based on Pulse Crops - 1990-94 and 1995-99

It is evident from the Table VIII that during 1990-94, only two districts of Kanpur Nagar and Kanpur Dehat form a pocket of high productivity with an index value ranging from 110 to 125 per cent. A majority of districts namely, Muzaffarnagar, Ghaziabad, Agra, Mainpuri, Fatehpur, Etawah, Etah and Allahabad fall under this category of medium productivity with an index value of 95 to 110. A set of six districts namely Meerut, Firozabad, Bulanhdshahr, Farrukhabad, Aligarh and Mathura show low productivity of pulses with the indices of productivity ranging between 80 and 95 per cent.

It is seen from Table VII that during 1995-99 there has been a considerable variation in productivity. The index of productivity for pulse crops ranges from a minimum of 56.40 to a maximum of 159.48 per cent. Only 6 districts namely, Kaushambi, Kanpur Nagar, Auraiya, Agra, Etawah and Kanpur Dehat, show high productivity, with the index values ranging from 105 to 130 per cent (Table VIII).

The districts having the index value between 80 and 105 (Table VIII), are classed as the medium productivity regions. The productivity of medium order is found in the districts of Kannauj, Fatehpur, Muzaffarnagar, Farrukhabad, Allahabad, Etah, Baghpat, Firozabad and Mainpuri. The remaining districts having an index value between 55 and 80, are classed as the low productivity region. These districts are namely, Meerut, Aligarh, Hathras, Mathura, Ghaziabad, Bulandshahr and Gautambudh Nagar.

In general the productivity in pulses shows a scattered pattern, with

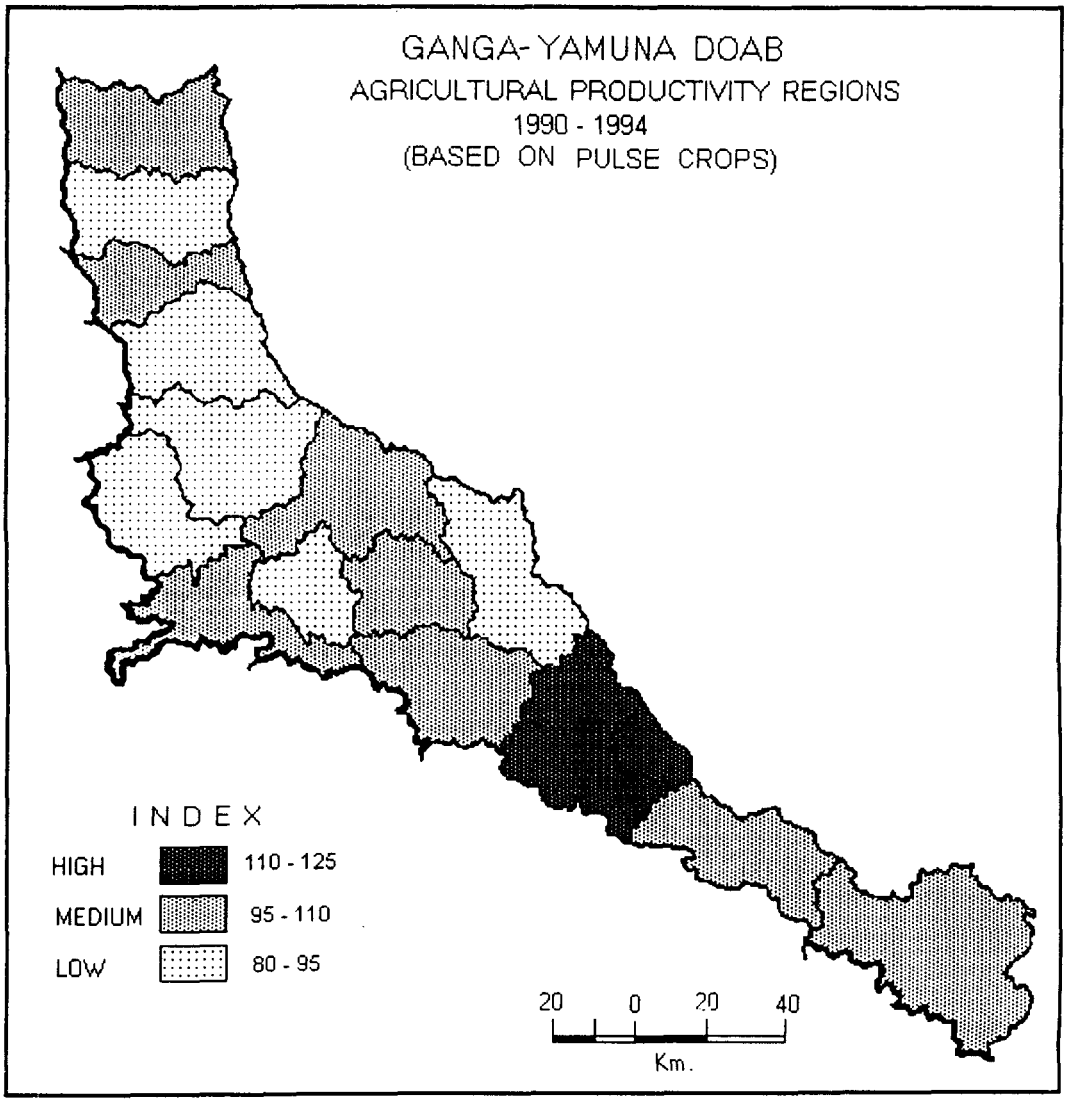
GANGA-YAMUNA DOAB
AGRICULTURAL PRODUCTIVITY REGIONS
1990 - 1994
(BASED ON PULSE CROPS)
INDEX
HIGH
110 - 125
MEDIUM
95 - 110
LOW
80 - 95
20
0
20
40
Km.

Fig. 8

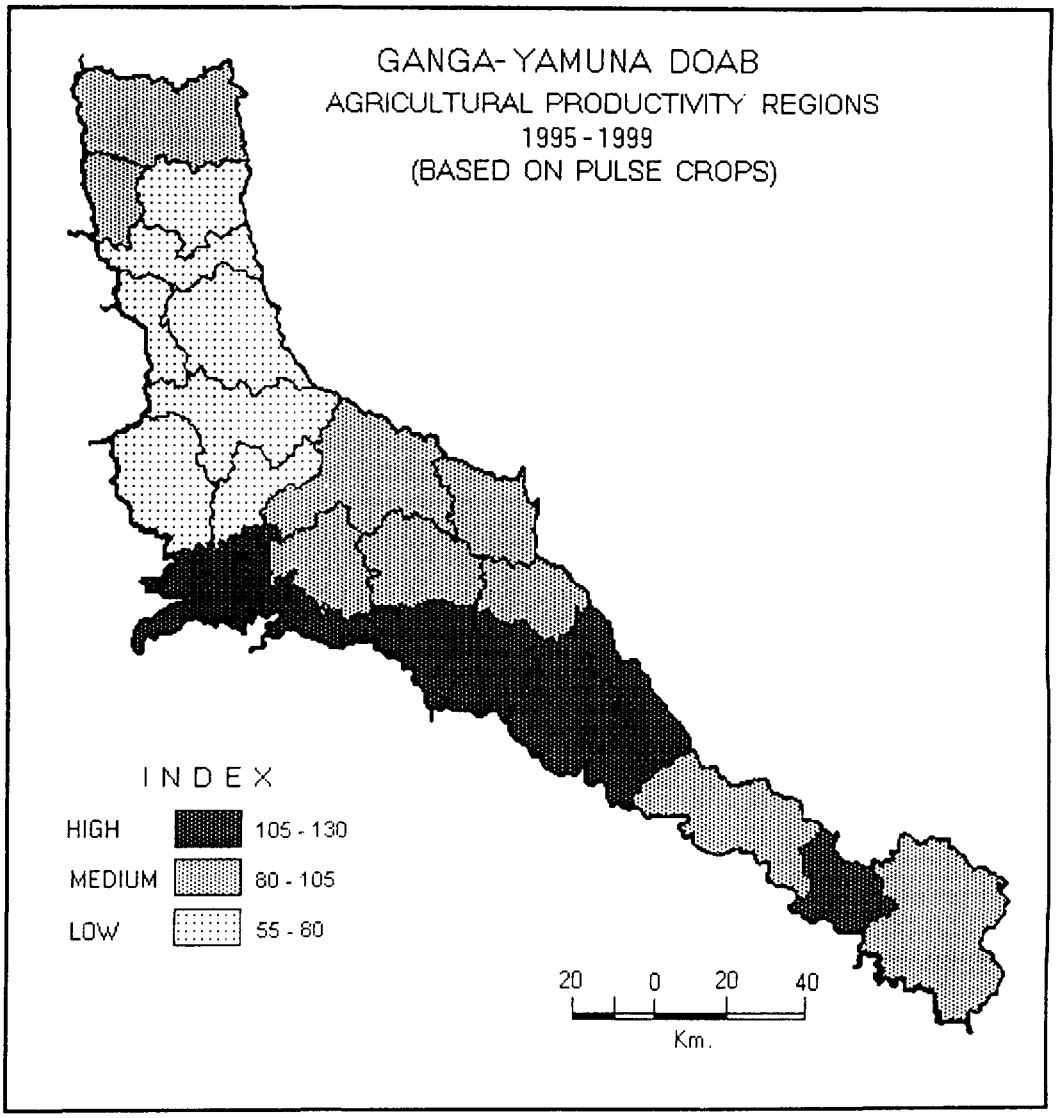
GANGA-YAMUNA DOAB
AGRICULTURAL PRODUCTIVITY REGIONS
1995-1999
(BASED ON PULSE CROPS)
INDEX
HIGH
105 - 130
MEDIUM
80 - 105
LOW
55 - 80
20
0
20
40
Km.

Fig. 9

no specific pockets of concentration in the Doab. Generally the areas of high productivity in cereals occurs in association with low productivity of pulses and vice-versa.

c. Productivity Regions : Based on Oilseeds - 1990-94 and 1995-99

The oilseeds constitute a significance in state's agriculture. They have acquired a special attention very recently because of a decrease in area of cultivation which has resulted a fall in production of oilseeds. It is evident from the Table VIII, that during the period 1990-94 only three districts namely, Agra, Ghaziabad, and Etawah in the region show a high productivity in oilseeds with the index value ranging between 105 and 135. Eleven districts having the index value between 75 and 105, fall under medium productivity region. They are the districts of Firozabad, Muzaffarnagar, Meerut, Bulandshahr, Aligarh, Mathura, Mainpuri, Etah, Farrukhabad, Kanpur Nagar and Kanpur Dehat. The districts of Fatehpur and Allahabad fall under the low productivity with an index value ranging between 45 and 75 per cent.

During 1995-99, the area under high productivity with the index value between 130 and 170 per cent confined to five districts namely Gautambudh Nagar, Baghpat, Auraiya, Hathras and Kannauj (Table VIII). The regions having medium productivity with index value between 90 and 130 occupy 9 districts. An another set of districts show low productivity of oilseeds with the index value ranging between 50 and 90. There are eight districts, namely, Etah, Muzaffarnagar, Mainpuri, Bulandshahr, Kanpur Nagar, Kaushambi, Fatehpur and Allahabad.

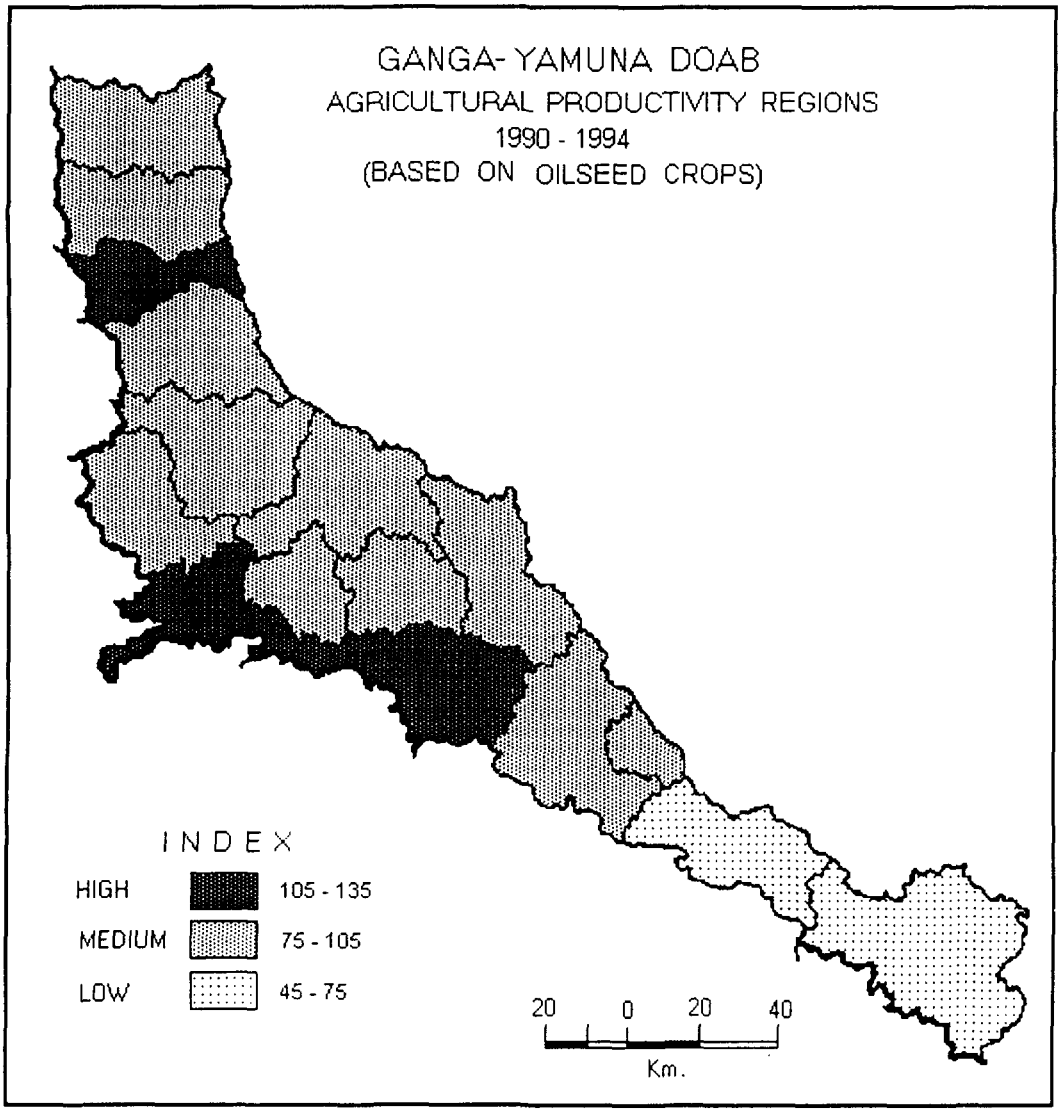
GANGA- YAMUNA DOAB
AGRICULTURAL PRODUCTIVITY REGIONS
1990 - 1994
(BASED ON OILSEED CROPS)
INDEX
HIGH
105 - 135
MEDIUM
75 - 105
LOW
45 - 75
20
0
20
40
Km.

Fig. 10

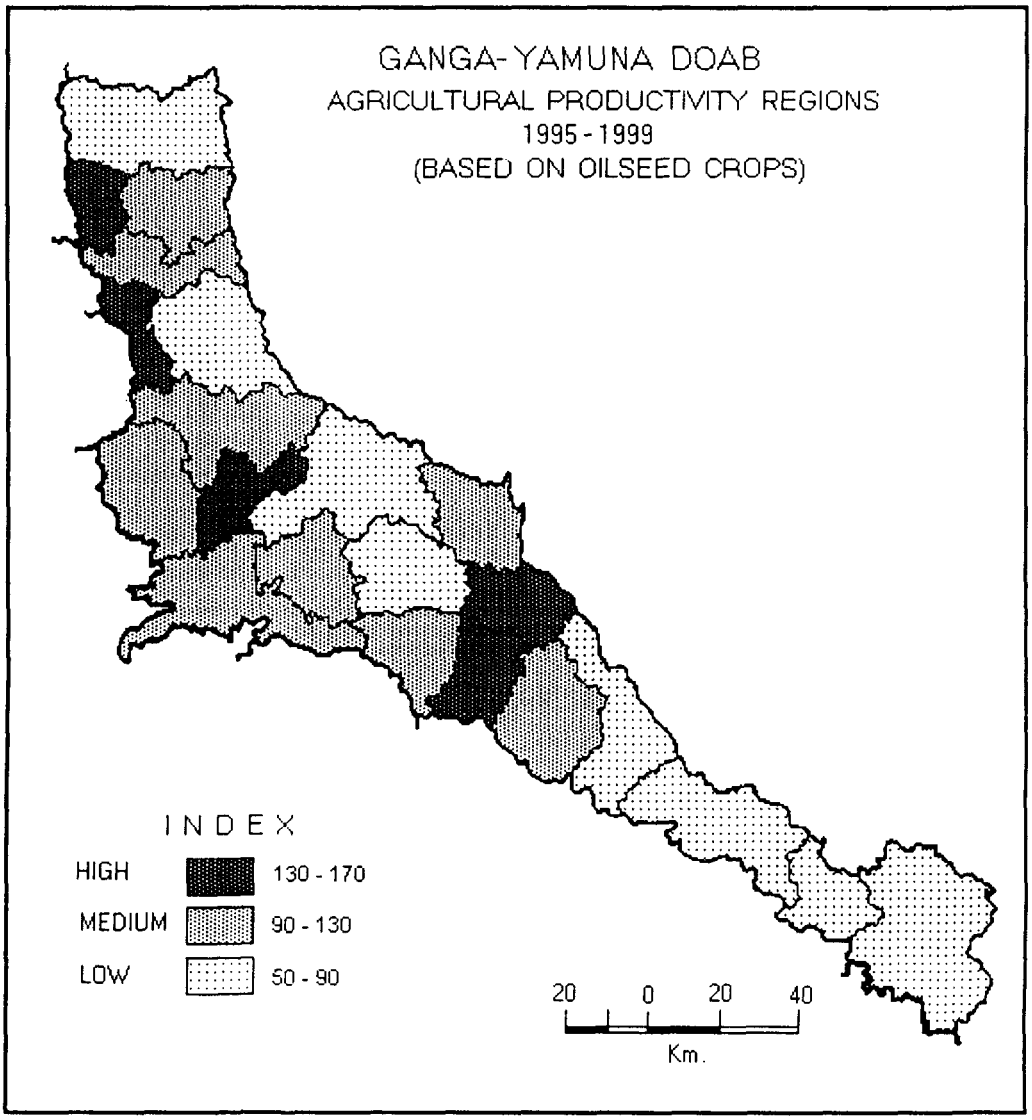
GANGA-YAMUNA DOAB
AGRICULTURAL PRODUCTIVITY REGIONS
1995 - 1999
(BASED ON OILSEED CROPS)
INDEX
HIGH
130 - 170
MEDIUM
90 - 130
LOW
50 - 90
20
0
20
40
Km.

Fig. 11

d. Productivity Regions : Based on cash crops - 1990-94 and 1995-99.

Among the cash crops sugarcane and potatoes were considered on account of relatively a sizeable area devoted in their cultivation. Cultivation of these crops has acquired significance as they altogether cover 11.12 per cent of the total cultivated area in Doab. It is clear from Table VIII that the high productivity areas with an index value between 100 and 115 per cent, occur in seven districts namely, Muzaffarnagar, Meerut, Ghaziabad, Bulandshahr, Mainpuri, Agra and Firozabad.

The medium productivity with and index value ranges from 85 to 100 to include the districts of Aligarh, Mathura, Farrukhabad, Kanpur Dehat and Allahabad. The areas marked with low productivity with an index value from 75 to 85 occur in five districts namely, Etah, Kanpur Nagar, Etawah and Fatehpur.

It is seen from Table VII, that productivity indices indicate the lowest index value of 65.43 for the district of Kannauj and a maximum value of 122.10 for the district of Agra. The high productivity areas are seen in three districts namely, Agra, Hathras and Firozabad, having an index value of in between 105 and 125. The medium productivity areas spread over to include 13 districts of the Doab with an index value ranging from 85 to 105 per cent. The areas marked with low productivity with an index value of 65 to 85 are confined to 6 districts namely, Etah, Fatehpur, Kanpur Nagar, Kaushambi, Kannauj and Allahabad.

Table VIII

Ganga-Yamuna Doab - Crop Yield Index

Period	Category	Cereals		Pulses		Oilseeds		CashCrops		Composite Index	
		Indices	No. of districts	Indices	No. of districts	Indices	No. of districts	Indices	No. of districts	Indices	No. of districts
1990-94	High	125-145	3	110-125	2	105-135	3	100-115	7	110-125	2
	Medium	105-125	7	95-110	8	75-105	11	85-100	5	95-110	11
	Low	85-105	6	80-95	6	45-75	2	70-85	4	80-95	3
1995-99	High	115-135	4	105-130	6	130-170	5	105-125	3	105-120	5
	Medium	95-115	14	80-105	9	90-130	9	85-105	13	90-105	11
	Low	75-95	4	55-80	7	50-90	8	65-85	6	75-90	6

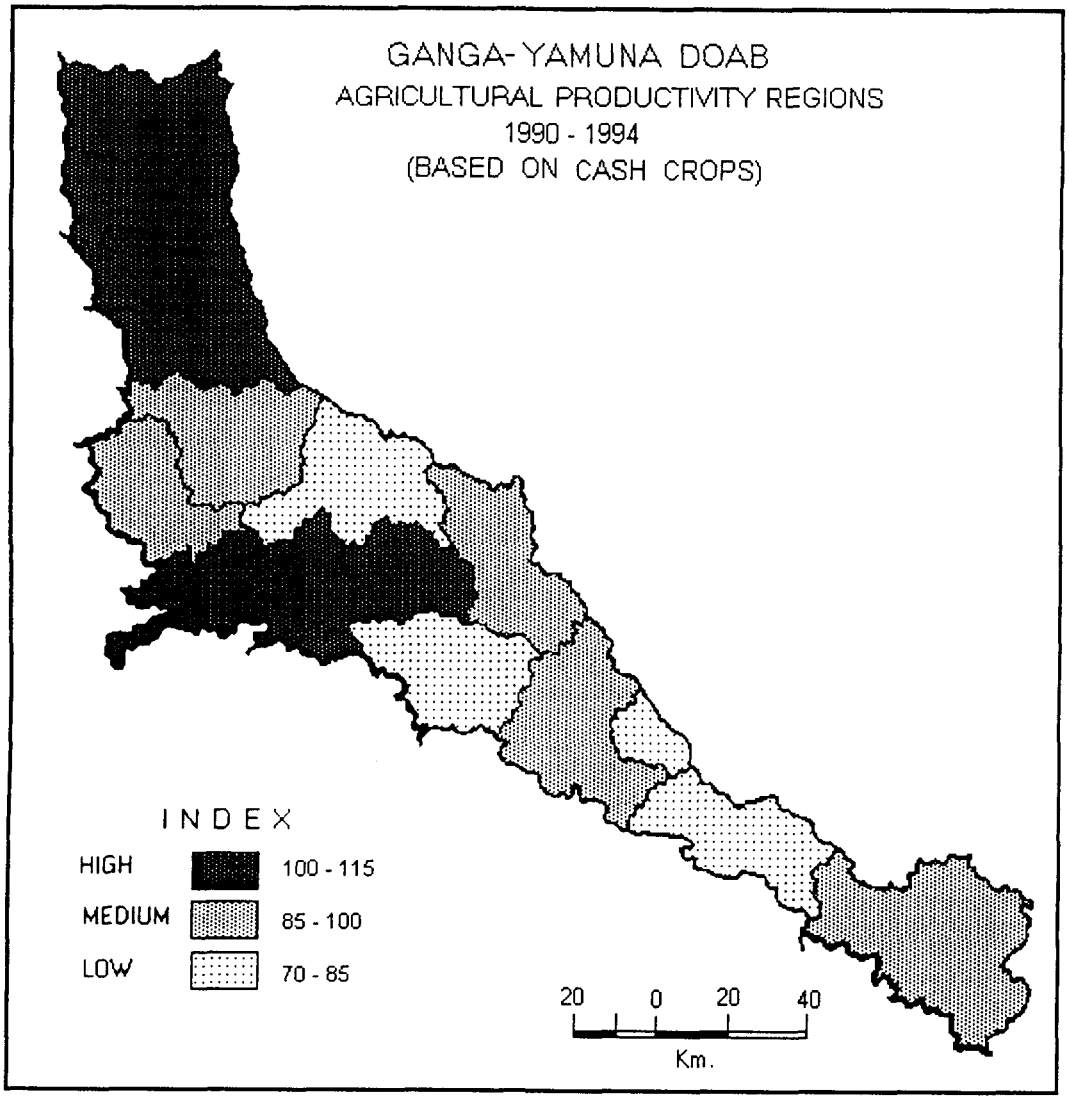
GANGA-YAMUNA DOAB
AGRICULTURAL PRODUCTIVITY REGIONS
1990 - 1994
(BASED ON CASH CROPS)
INDEX
HIGH
100 - 115
MEDIUM
85 - 100
LOW
70 - 85
20
0
20
40
Km.

Fig. 12

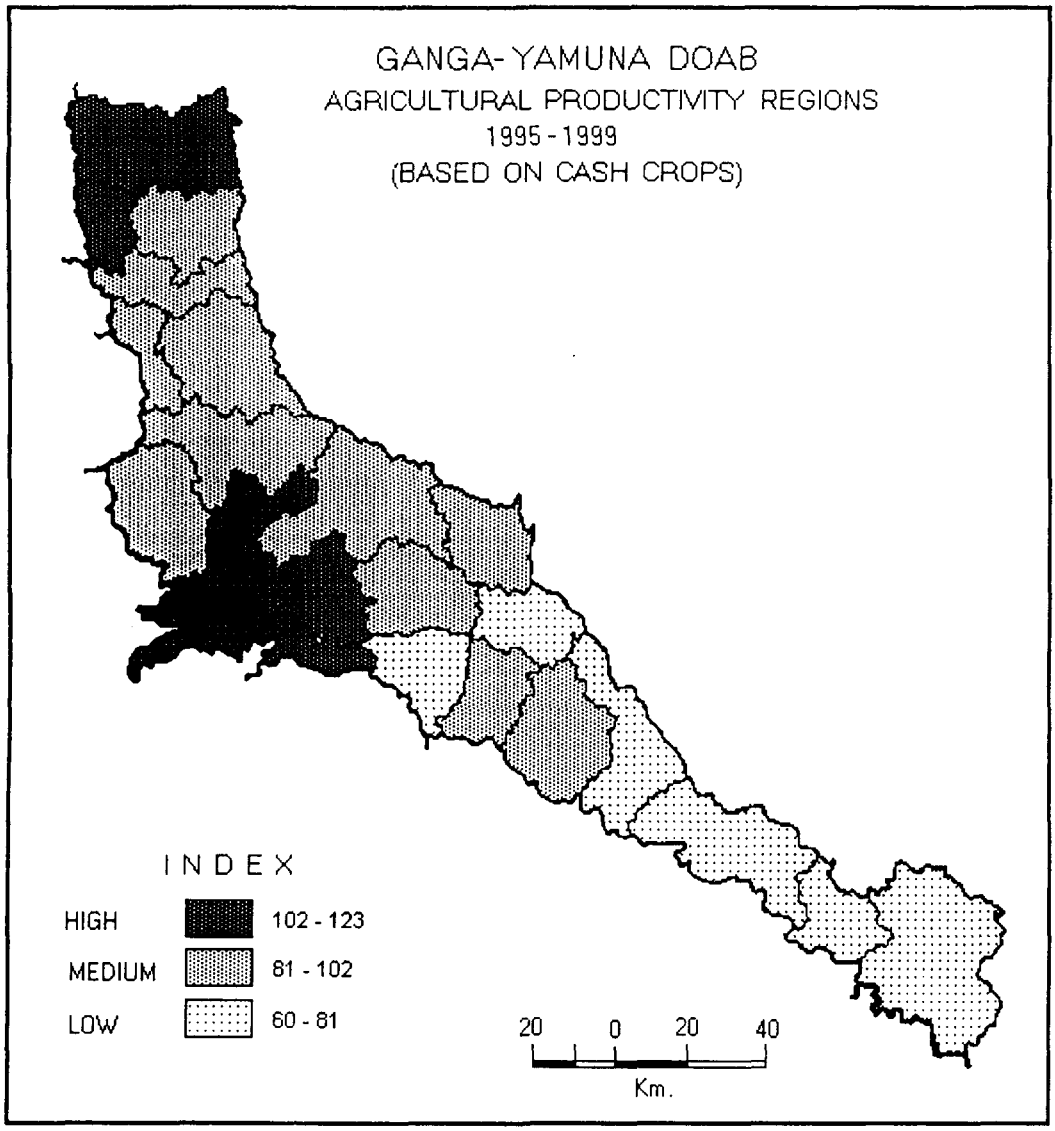
GANGA-YAMUNA DOAB
AGRICULTURAL PRODUCTIVITY REGIONS
1995-1999
(BASED ON CASH CROPS)
INDEX
HIGH
MEDIUM
LOW
102 - 123
81 - 102
60 - 81
20 0 20 40
Km.

Fig. 13

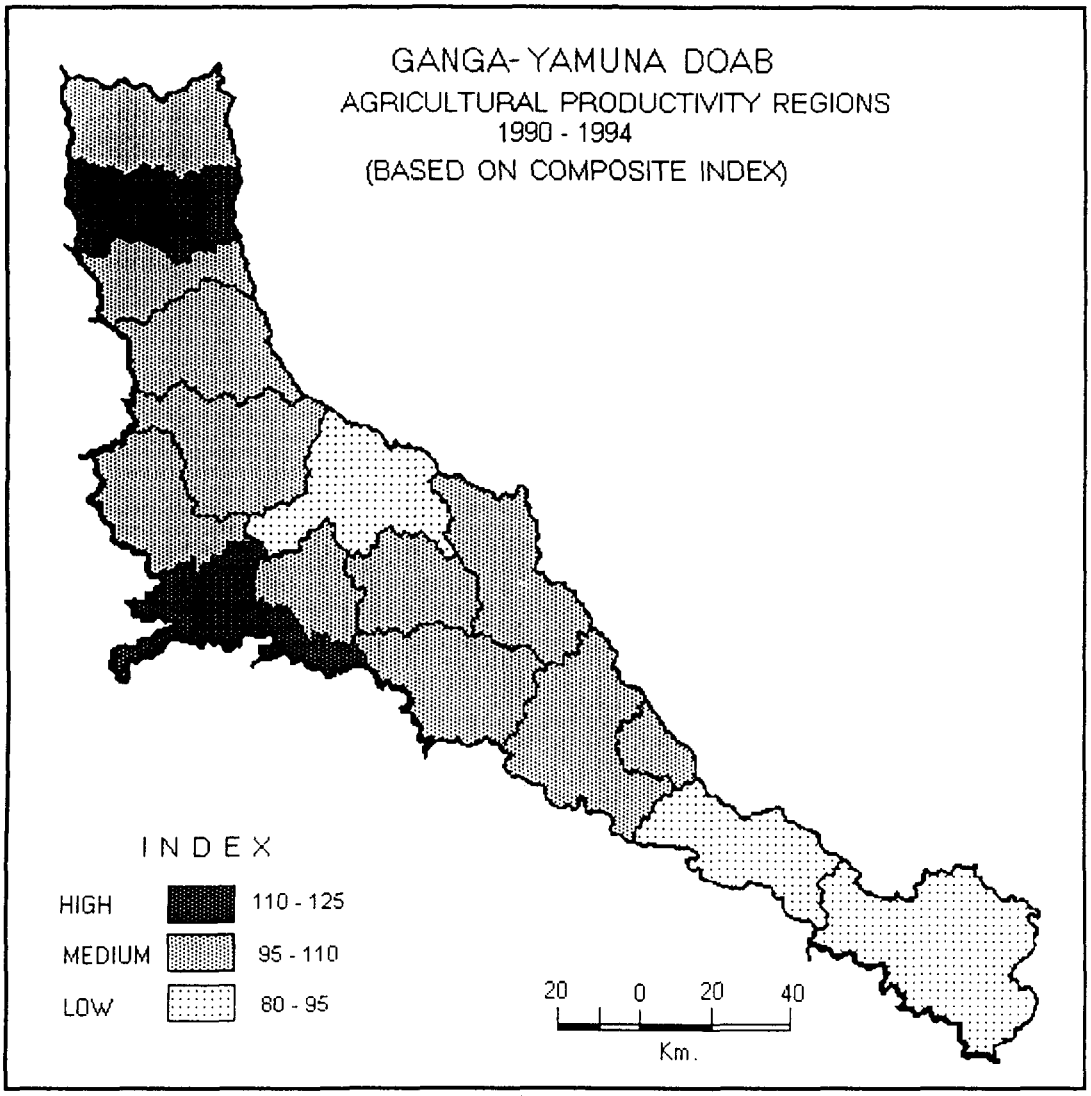
GANGA-YAMUNA DOAB
AGRICULTURAL PRODUCTIVITY REGIONS
1990 - 1994
(BASED ON COMPOSITE INDEX)
INDEX
HIGH
110 - 125
MEDIUM
95 - 110
LOW
80 - 95
20
0
20
40
Km.

Fig. 14

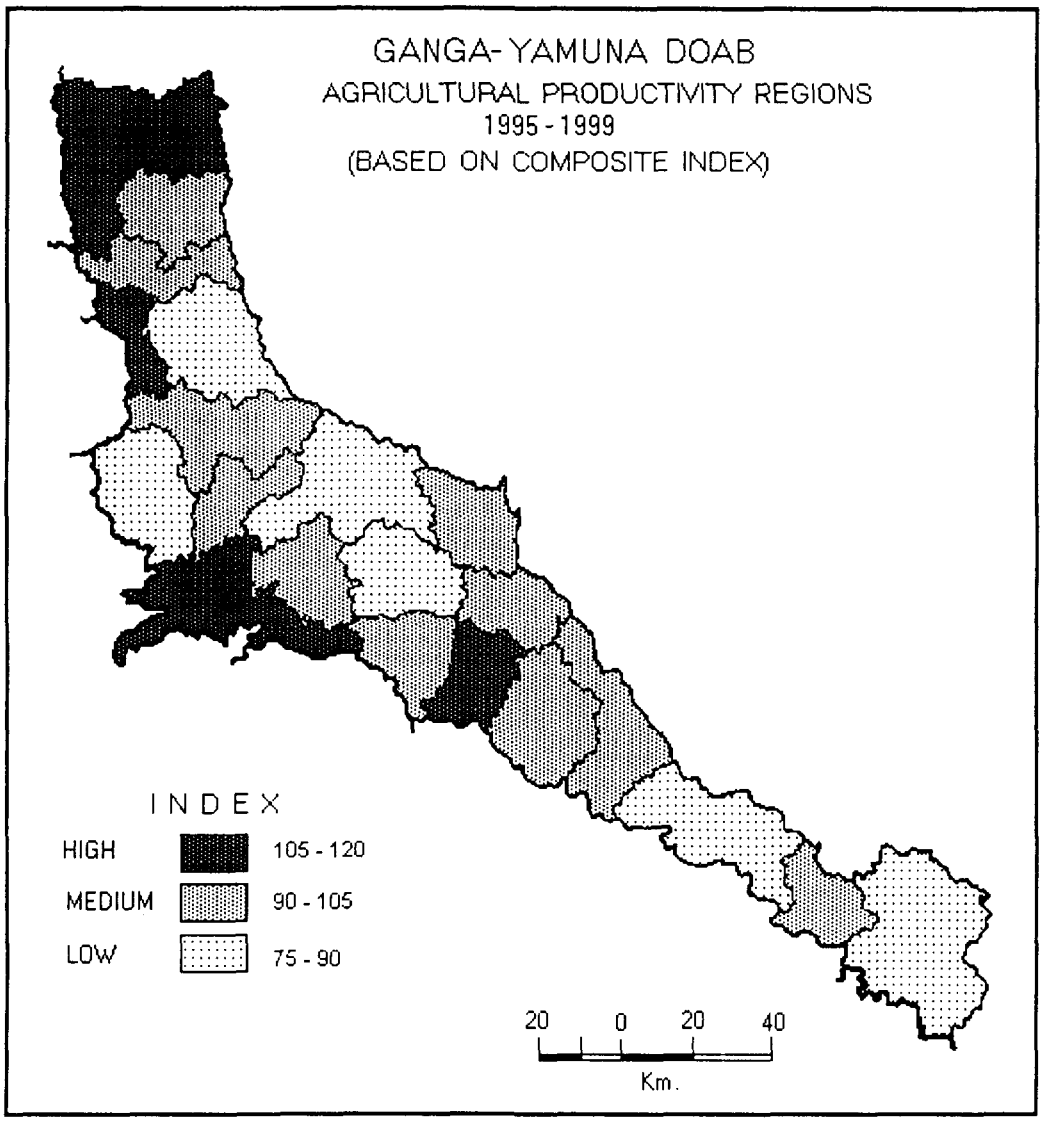
GANGA-YAMUNA DOAB
AGRICULTURAL PRODUCTIVITY REGIONS
1995 - 1999
(BASED ON COMPOSITE INDEX)
INDEX
HIGH
105 - 120
MEDIUM
90 - 105
LOW
75 - 90
20
0
20
40
Km.

Fig. 15

B. Determinants of Agricultural Productivity

There are a number of factors which act as the determinants in the plant growth. The growth of plant and the quantum of crop production depends upon physical, institutional and technological factors. Among physical factors, the amount of rainfall, temperature, and sunshine are mainly responsible for the growth of crops. Soil and its constituent nutrients determine the yield of crops. Among the technological factors crop productivity depends upon the use of high-yielding varieties of seeds, manures, fertilizers, agricultural implements, insecticides and pesticides and other related management practices. Ownership of land, size of land holding and tenancy are some of the important institutional factors which also affect the productivity.

The environmental factors are the major deciding factors in crop cultivation. The climate of a region governs the type of crops to be sown and related yields that can be obtained. The climate constitutes the temperature, sunshine, rainfall, wind and precipitation. For the optimum growth of crop all the factors contribute in balanced form as per requirements of crops.

All plants need a certain amount of temperature for growth. A combination of abundantly high temperatures in association with adequate precipitation throughout the year, the growth of plants may appreciably be healthy. Diurnal range of temperature affects cropping, yield per hectare and finally the crop quality. For example, potatoes do well only in areas which are characterised with cooler nights and warmer days; maize can be cultivated advantageously in areas where days and nights are warm. For the successful cultivation of wheat low winter temperatures are most suited. The incidence

of sunshine hours affects the cultivation of crop by two ways: (i) by limiting the number of crops that can be grown profitably, and (ii) by affecting the yield of crops grown. The second affect of sunshine is on the yield of crop and consequently the profitability.

Crop yields are affected very often by the occurrence of frost. There are two kinds of frost which may be distinguished as :

(i) advection or airmass frost, which results when the temperature at the surface in an airmass is below freezing point, and (ii) radiation frost, which generally occurs in cloudless nights with a temperatrure inversion and usually results in formation of crystals. This hazard is greatest during the critical stages of plant growth. Crop like potatoes, tomatoes and melons are adversely affected during maturity period.

Rainfall is one of the most important factors affecting crop productivity, rainfall provides moisture to soil. Crop cultivation, however, does not depend only on rainfall, but it depends to on other factors concerned with the hydrological equation, which may be expressed as

$$P = E + R + D + S$$

where

P = Precipitation

E = evapo-transpiration

R = Surface run-off

D = the rain water which drains beyond the root range of plants down into the deep sub soil on the parent rock and

S = the amount of water stored in the soil

The extent to which the rainfall in an area can provide soil moisture depends not only on the total amount of rainfall that area receives per annum, but it is its seasonal distribution within and between seasons, intensity of occurrence and rate of infiltration into the soil, and on the balance between rainfall and evapo-transpiration from the crop and soil.

Wind affects productivity indirectly through the transport of moisture and temperature properties of the air, movement of air which increases the evapo-transpiration. Strong winds affect the plant structure and the pollination activities of insects.

Soil is another important factor which determines the productivity of crops. It is the fertility of soil, which controls the plant growth. Soils having all the essential nutrients for plants are characterised to be productive. Many of the productive soils support luxuriant crop growth. In between the categories with high and low fertility, there are the soils, which must be fertilized, irrigated and drained to make them desirably productive. A little amount of calcium even for a day in the soil may reduce crop yields. If the soil is tough and crusty, it is too wet with rain and too dry a few days later, plant growth is stunted. To be more specific, all crops need the same amount of nutrients in addition to water and air, but they differ in the relative amount of nutrient requirements. For example, bajra, lucerne and rice, all require the same nutrients, air and water. But bajra can be grow on soils with very low of nutrients and water, while lucerne requires a very fertile soil which should constantly receive moisture. On the other hand lucerne and rice both have high water requirements; but lucerne must have plenty of air mixed with the water, where rice yields acts better when the soil is flooded. The soil consists

of four major components: mineral matter, organic matter, air and water. Mineral matter forms the bulk of the soil (by weight of about 90 per cent).

The elements, needed for the plant growth are: carbon, hydrogen, and oxygen from air and water, phosphorus, potassium, sulphur, calcium, iron, magnesium, copper, zinc, molybdenum and chlorine from the soil, and nitrogen from both soil and air. Nitrogen, phosphorus and sulphur in soils are the constituents of organic matter. These three nutrients become available to plants only after biological decomposition.

Physical properties of the soil greatly influence the plant growth which depend on the amount, size, shape, and mineral composition of particles. The amount of organic matter and volume of pores. Soil texture refers to the relative proportions of sand, silt and clay that are present in soil. A large amount of sand mixed in soil makes it coarse and gritty. Such soils are light and are called sandy or sandy-loams. If silt is present in large quantities, the soil is of medium texture and is known as silt-loam or loamy. On the other hand, a large amount of clay in soil makes it sticky when wet and hard-dry. Such soil is heavy and called as clay or clay-loam. For the determination of suitability of cultivation the medium textured soils are considered to be the best as they have much moisture holding capacity and allows much aeration to plant roots. Soil structure refers to the way in which individual particles are joined into clusters and separated from other clusters. The four primary types of soil structures are : granular, blocky, platy and single grain. The soil structure has a direct relationship with soil fertility, permeability and root growth. The colour of soil varies widely amongst horizons of a soil profile. The colour of the top soil is indicated by the

drainage of the area. Well drained and moderately drained soils have generally a uniform brown colour, than moist, but in some case they may have various shades of red or yellow colour. A black soil surface usually indicates that soil is either rich in organic matter or it has remained wet for long period.

Soil erosion is the wearing and removal of soil from the surface by natural agencies such as running water, wind, glaciers and ocean or sea waves. Under normal, physical, biotic and hydrological equilibrium in nature, the erosion that takes place is normal or natural, where in soil removal is fairly balanced.

Soil erosion results in by a number of factors. Among them, some of the factors are associated with: (i) climate, (ii) topography with special reference to degree and nature of slope (iii) physical and chemical characteristics of soil (iv) nature and extent of ground cover (v) natural hazards, such as earthquakes, upheavals and landslides, and (vi) landuse and farming practices.

Due to erosion the top soil is removed and thus the fertility of it is declined. It is estimated that the annual loss of fertility by erosion is twenty times faster than that is removed by the crops when cultivated. Running water continues to carry away the top soil, subsequently the productivity of land is declined. Soil erosion not only reduces the yield of crops on denuded slopes but also reduces the productivity of level lands. Frequent floods deposits large quantities of coarse sands and gravels which bury the surface soils in low lying areas. Severe cutting of river banks may destroy fertile agricultural lands.

The basic aim of soil conservation is to reduce soil losses and to maintain the overall productivity of the land. The most important requirement is to keep the land under cover as long as possible and to encourage more water to enter into the soil and to reduce the amount and velocity of run-off to a minimum extent. The common and more oftenly adopted practices for soil and water conservation are the strip cropping, crop rotation, mulching, planting of grasses and trees, contour tillage, contour bunding, terracing, the construction of ponds and reservoirs, and the control of gullies along the stream banks.

The use of fertilizers has been one of the important factors in raising agricultural productivity. Infact the quantity of fertilizers on cultivated land is closely linked to the selection of crops. Each crop requires different amounts of fertilizers. The experience with the adoption of high-yielding varieties has given us chance of condidence by breeding of fertilizer responsive varieties. With the selection of suitable seed variety, the next input which can bring production on a massive scale is fertilizer. A study of developed countries highlighting the progress, shows remarkable results in crop production by increasing the consumption of fertilizer per unit area. Thus, efforts are continually being made to evolve new varieties which have many more times the production potential than the traditional ones. For exploiting the potentials of new varieties, agronomic practices have to be evolved, based on the use of fertilizers and manures, especially the nitrogenous ones.

Fertilizers are often regarded as substitute for animal manure as they improve soil conditions and supply nutrients. The use of commercial

fertilizers makes it possible to introduce extra-supplies of nutrients into the cycles of growth and decay and thus improve soil fertility. Use of animal and green manures contribute directly to the soil organic matter, and fertilizers do so, indirectly by increasing the quantity of crop residues available for incorporation into the ploughed fields. Nitrogen, phosphorus and potassium are required by the plant in large amount and therefore, they are known as the primary nutrients. Whereas, calcium, magnesium and sulphur are the secondary nutrients. The deficiency of these nutrients is generally met with the use of the fertilizers belonging to nitrogen, phosphorus and potassium.

The quality of fertilizers to be applied to each crop depends upon the presence of nutrients in the soil and the crop requirements. In regions of heavy rainfall, nitrogen is rapidly leached into the soil. Rice, millet, sorghum and sugarcane show increased yields with the application of nitrogen fertilizers. In rice growing areas phosphate is often considered as important as nitrogen. Phosphate increase the rooting and tillering of rice, making it more resistant to water shortage. The effect of potash on sugarcane varies with the soil and rainfall. The sugar content of the cane is frequently increased by the use of potash.

The high-yielding varieties of crops offer an unprecedent opportunity for a breakthrough in agricultural productivity. They are adopted with suitable combination of inputs particularly, fertilizers, water and plant protection chemicals for raising yields several folds. The performance of improved varieties must be considered in relation to ecological environment. Since the high yielding varieties of cereals make it possible to grow a

country's cereal requirements. The potentials of cereal varieties can be achieved only if they are used in conjunction with adequate input of fertilizers and water, careful attention of protection, and adopting better farm practices. Maxican varieties of wheat demand at least two or more irrigations than the local ones. In some areas rice fields have an excess rather than a deficiency of water. Pests and diseases pose another problems. In addition to crop protection measures, it is essential to develop a number of disease resistant varieties.

Agricultural productivity greatly depends on timely availability of water and its management. Irrigation is the controlled application of water to crops, to supplement the soil moisture. Assured and controlled water supplies are one of the essential requirements of high-yielding varieties of cereals and other crops. The affect of irrigation on productrivity is such that if 10 per cent of cultivated land that is irrigated may be roughly estimated to contribute about 20 percent of total agricultural productivity.

While the expansion of the irrigated area can greatly increase agricultural productivity, much can also be achieved by increasing yields on land already irrigated. Bringing new land under irrigation is usually both time consuming and costly. Increasing yield on land already irrigated contributes to maximizing the returns from costs that have already been incurred. Improvements in irrigation efficiency or supplemental irrigation can double or triple production in many existing irrigated areas.

Mechanization of agriculture has resulted in increase in agricultural productivity and reduction of cost. By mechanization we mean the

replacement of animate power by machinery, wherever it is possible. Ploughing is to be done by tractor, sowing and putting of fertilizers by the drill and reaping and thrashing by the combined harvest-thrasher and so on. Thus mechanization of agriculture stands for the use of machinery in all farming operations ranging from ploughing to the marketing of the produce.

Machines work faster and work accurately. Man by himself can produce only very little but with the help of machinery he can produce much more. What a farmer with a pair of bullock can plough in ten days, a tractor can do in one day and far deeper too. Secondly, farm machinery has relieved man of much of the heavy work. For instance land reclamation, digging and carrying plough are all heavy jobs. Output per hectare and per person can be increased. The cost of production is reduced.

Crop protection measures are also needed in increasing agricultural productivity. The increased yield obtained through the use of improved crop varieties, fertilizers and irrigation are in danger of being wiped out by pests and diseases. The tropical environment which favours the weeds which compete for moisture and epidemics. The methods followed by the native cultivators are frequently designed to reduce the loss of crop from pests and diseases, though they have been developed from experience rather than scientific investigation. These methods can often be improved upon by legislation, breeding and the use of chemicals.

The object of all control measures is to attack the parasite and defend and strengthen the host by the following : (i) keeping the pest out by strict plant quaratina (ii) destroying the outbreak pest (iii) destroying the alternate host plants (iv) rotating annual crops to prevent pest levels building

up, (v) biological control by introducing insects, fungi, which will attack the parasite (vi) destroying the resources of infection "cut and burn" (vii) chemical attack on the parasite, (viii) growing the crop at a time unfavourable to the pest (ix) breeding resistant varieties (x) legislation restricting the varieties grown to resistant ones, (xi) modifying the crop environment such as the amount of shade, water relationship and soil nutrient status, and (xii) applying a protective chemical.

Due to import of plant material many new pests and diseases have appeared. It is difficult to know whether a major pest of one area is absent from another area because it has never been introduced or whether it has been introduced but has not established itself due to unfavourable conditions. Too frequent cropping of a soil with the same crop can lead to build up a plant pest. In planning the rotation, the alternative crops should not be host to pest. The diseased material should be pruned from the trees, infected fruits collected where possible and burnt or burried. Sterilization or partial sterilization of the soil is usually out of the question except in nursuries and seedbeds.

If a crop can be grown the whole year round either because the rainfall is suitable or irrigation is practiced a continuous source of infection is provided. A crop grown at the time of year most suitable to its continued active growth will normally be more resistant to pests and diseases than a crop struggling against adverse conditions. The selection or breeding of crop varieties resistant to the important pests and diseases would be an ideal method or control. During the breeding of a variety resistant to one pathogen, the resistance which existed in the cultivated variety may be lost and an

important disease may be elevated. Resistant varieties are only of use in perennial crops when replanting or improving by grafting and thus are mainly applicable to annuals and short term perennials.

If all the factors relating to keep balance between crop and pest are known it would be possible in many cases to avoid a large proportion of the crop loss by modifying the plant environment. The majority of crops grown under fertile conditions with adequate moisture will often survive from pest or disease outbreak. Balanced fertilizer application is more inclined to protect a crop from attack than make it more susceptible. When an invasion by a fungus or an insect is anticipated, the crop can sometimes be protected by spraying, and the invasion is prevented from getting into the crop. This applies to systematic insecticides but more particularly to fungicides, where copper, the main fungicide used in tropics acts as a crop protectant.

Low agricultural productivity, however, is not only a technical determinant. It is no less a social and economic problem, and also a problem of organization. In all the districts of Doab is not the lack of technical knowledge, but the problem of transmitting that knowledge to millions of uneducated and often illiterate farmers, and perheps still more of creating environment which will enable them to put it into practice. The influence of land tenure systems is often over riding not only questions of ownership, which relate particularly to incentives to use improved technology, but also the frequently small and scattered nature of holdings, which greatly hampers the introduction of rotation, crop protection measures, and machinery. These small holdings lead to great waste of time, labour and cattle power difficulty in proper utilization of irrigation facilities, wastage of crops in the absence of

fencing etc. Other institutional factors include the poverty and lack of education of farmer and the orientation of production primarily to the subsistence of the producers and their families rather than to commercial production.

Extension services have a crucial role to play in helping farmers to avoid failures resulting from the use of the wrong plant variety, new pests and diseases and incorrect methods of sowing or fertilization. Therefore, it is essential that there should been effective agricultural extension services, with a suitable organization, an adequately trained staff, sufficient equipment and facilities for mobility. It is necessary to intensify applied research work in raising the agricultural productivity. It should be conducted in the ecological, economic and social context of the region.

Research services will help in selecting the most suitable varieties of seeds to be sown local conditions and in controlling pests and diseases. A national agricultural research programme should be established based on immediate problems of farmers and on long term requirements for agricultural development.

Credit facilities should be expanded for the purchase of inputs. Attention is also given to the needs of the farmers in relation to price of commodities in the market. The problems of input supply credit, marketing and storage can be met by cooperatives or other organizations. The need for effective organizations of these or other appropriate kinds is likely to increase as the use of modern technology becomes more widespread.

CONCLUSION AND SUGGESTIONS

The objectives to undertake the present study are to ascertain the spatial variations in agricultural productivity in the Ganga-Yamuna Doad. Infect agricultural productivity in any region is the result of interaction of natural, socio-economic and technological factors. In the present study it is attempted to delineate the areas which are characterised with high, medium and low productivity. The study also a stock of changes in land use and the productivity that have taken place during the last two periods of time from 1990-94 and 1995-99.

In the being, an attempted has been made to consider landuse profile which concludes the areas under waste land, culturable waste land and fallow land have decreased, while there is an increase in net sown area. The changes in land utilization have been due to the adoption of new farming techniques. In consequence of this, the area under waste land, culturable waste and fallow land is well undertaken by the farmers under cultivation. Further, an attempt is made to examine the area, production and yield under the selected 13 crops which were grouped into four broad categories : cereals, pulses, oilseeds and cash crops. The changes in cropping pattern for each of 13 crops considered in terms of area and production have been examined. There is a marked variation in area and production of cereals, pulses, oilseeds and cash crops. Cereal crops show a positive growth in area and production to the extent of 1.63 and 1.13 per cent respectively. The cereals (rice, wheat, maize and bajra) show a positive growth in production of about 27, 16, 19 and 29 per cent, whereas the jowar and barley show a negative growth of about 11 and 2 per cent, respectively.

In case of pulse crops, both the area and production have declined and show a negative growth of about 1 and 12 per cent, respectively. The oilseed crops show a slight increase and decrease in area and production, but a constant increase in yield per hectare.

The cash crops (potatoes and sugarcane) show a substantial increase in area and production. These crops have attained a highest positive growth as compared to the foodgrains and oilseed crops. The sugarcane and potatoes show a growth of 6.8 and 11.64 per cent in area and in production, they accounted for about 10 and 40 per cent, respectively.

The changes recorded in cropping pattern are due to the adoption of modern technology, better irrigation facilities, use of HYV of seeds, impoved farm implements, consumption of fertilizers and government policies.

The crop-combination regions were determined as the basis of considering the area under the crops during periods 1990-94 and 1995-99. Further, it was attempted to determine the agricultural productivity and demarcate the productivity regions in the Ganga-Yamuna Doad on the basis of Yang's 'Crop Yield Index' method. The study reveals, that the districts comprising the upper Doab have high productivity (with the exception of pulse crops), and the districts that of the lower Doab are characterised with low productivity.

The general pattern of agricultural productivity shows a marked decline in productivity from north, northwest to southeast. This pattern is closely related with a general variations in the application of agricultural technology by the farmers.

In conclusion, it can be mentioned, that in the districts of upper Doad, where the farmers have relatively higher income and farms are technologically more advanced, the landuse pattern and yield per hectare generate higher incomes.

SUGGESTIONS :

1. In order to develop the least developed districts of the Ganga-Yamuma Doab, it is necessary to increase productivity per unit of cultivated land.

2. Efforts should be made for the promotion of house-hold and cottage and agro-based industries, so that the surplus man-power can gainfully be employed during the lean months.

3. An assured provision of irrigation is also needed for the timely supply of water to the crops.

4. Proper recommendations be made to the farmers for the use of bio-fortilizers instead of chemical fertilizers.

5. To prevent water-logging and soil erosion, the concrete embankments should be made along the flow of canals. Soil erosion could also be prevented by planting trees along either sides of the canals.

6. Cost of inputs should be reduced and subsidies must be provided to assist the marginal and small farmers.

7. Bank loans and credit facilities should be available and distributed on easy terms.

8. Extensions services and proper education regarding the latest developments in agriculture and price incentives should be provided to the farmers very oftenly.

9. Storage facilities should further be increased so that the agricultural commodities be stored properly.

10. Proper transportation facilities be provided to the farmers for brining their crop outturn to the market yards.

11. Crop insurance scheme will be of much help to the farmers against the risk and uncertainty of crop failure.

12. Finally, it is much needed the working of credit institutions and administrative procedures be made easy so that small and marginal farmers can also get benefits from them.

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